Alameda Watershed Management Plan
Peninsula Watershed Management Plan

APPENDIX C
VOLUME I

San Francisco Public Utilities Commission

November 1998

List of Appendices

The following documents and memoranda were prepared during the course of the watershed management planning process. This information was gathered at specific points in time during the planning process and does not necessarily represent the information contained in the Alameda Watershed Management Plan. Some specific issues noted in the following appendices may have been refined through the planning process. These refinements are reflected in the Alameda Watershed Management Plan.

The items shaded in the List of Appendices below are bound together in this volume.

Appendices A and B are not listed below as they are specific to the Peninsula and Alameda Watershed Management Plans and their contents differ.

Appendix C. Peninsula and Alameda Watersheds: Surveys and Technical Memoranda[2]

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- Volume 6, Fall 1996
- Volume 7, Summer 1997 (to be completed)
- Volume 8, Fall 1997 (to be completed)

D-14 Brochures

- Coordinated Water Management: An Orientation to the Water System of the City and County of San Francisco

[1] *Material in this Appendix covers both the Peninsula and Alameda Watersheds, and therefore it is a common Appendix to both the Peninsula Watershed Management Plan and the Alameda Watershed Management Plan.*

Appendix C-1

Watershed Sanitary Survey for the Alameda and Peninsula Watersheds
October 1995

San Francisco Water Department

Watershed Sanitary Survey for Alameda and Peninsula Watersheds

October 1995

Prepared for EDAW, Inc. by

MONTGOMERY WATSON

SAN FRANCISCO WATER DEPARTMENT

WATERSHED SANITARY SURVEY
ALAMEDA AND PENINSULA WATERSHEDS

OCTOBER 1995

PREPARED FOR EDAW, INC. BY

MONTGOMERY WATSON, WALNUT CREEK

SAN FRANCISCO WATER DEPARTMENT

WATERSHED SANITARY SURVEY
ALAMEDA AND PENINSULA WATERSHEDS

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EXECUTIVE SUMMARY

INTRODUCTION

- The California Surface Water Treatment Regulations requires that all surface water purveyors of drinking water conduct a watershed sanitary survey of their systems by January 1, 1996 and update it every five years thereafter. This watershed sanitary survey was conducted to fulfill these State requirements for the San Francisco Water Department's (SFWD) local watersheds. It was prepared as a part of the development of the San Francisco Watershed Policy and Management Plans which will be adopted in 1996. The Management Plans for the Alameda and Peninsula watersheds will provide additional recommendations for the protection and improvement of water quality.

- The primary objectives of this survey are:

  - To fulfill the requirements of Title 22 of the California Code of Regulations, Article 7, Section 64665 by utilizing the American Water Works Association Watershed Sanitary Survey Guidance Manual;
  - To survey for and describe the potential contaminant sources within the watersheds upstream of the treatment plant intakes, focusing primarily on SFWD lands;
  - To summarize raw water quality data to indicate parameters of concern;
  - To evaluate the treatment plants' ability to meet surface water treatment regulations; and,
  - To provide a master plan of source water quality protection actions for SFWD to aggressively pursue and implement as the opportunities arise.

WATER SUPPLY, CONVEYANCE, AND TREATMENT SYSTEMS

- The SFWD provides drinking water to 2.3 million people and is currently providing an average daily supply of approximately 273 million gallons. About 35 to 40 percent of the consumption is within the City and County of San Francisco. The remaining supply is provided to 30 wholesale water purveyors along the southern half of the San Francisco Bay.

- Three primary sources provide the surface water supplies for the entire system: the Tuolumne River in the Sierra Nevada mountains via the Hetch Hetchy system; surface runoff captured from the Alameda watershed and stored in San Antonio and Calaveras Reservoirs; and surface runoff captured from the Peninsula watershed and stored in Pilarcitos, Crystal Springs, and San Andreas Reservoirs. About 80 to 85 percent of the potable supply to SFWD customers is from the Hetch Hetchy system. During the recent drought, water was also purchased (years 1991 and 1992) from the State to augment the primary supplies. Although only 15 to 20 percent of the total supply is from local runoff, these reservoirs also store Hetch Hetchy and other imported waters.

ALAMEDA WATERSHED CONDITIONS

- The southern Alameda Creek watershed area consists of 175 sq. mi. and drains to SFWD collection systems (San Antonio and Calaveras Reservoirs and the Sunol Filter Galleries). The SFWD owns approximately 63 sq. mi. within this 175 sq. mi. study area. The watershed is within both Alameda and Santa Clara Counties.

- The study area contains four drainage basins: 1) Calaveras drainage area which includes Arroyo Hondo lands (including the tributaries Smith and Isabel Creeks which circle Mount Hamilton) and lands adjacent to the Calaveras Reservoir; 2) upper Alameda drainage area which includes Alameda Creek lands upstream of the Alameda Diversion Dam; 3) San Antonio Reservoir drainage area with San Antonio, Indian, La Costa, and Apperson Creeks draining the entire watershed; and 4) lower Alameda Creek drainage area which includes lands downstream of the Alameda Diversion Dam and downstream of the two reservoirs, all of which drains to the Filter Galleries.

PENINSULA WATERSHED CONDITIONS

- The Peninsula watershed is approximately 36 sq. mi. and 99 percent of the lands are owned by SFWD. It is located in San Mateo County. The Crystal Springs Reservoir is located on the San Andreas and San Mateo Creeks. San Andreas Reservoir is on the northern branch of the San Andreas Creek above Crystal Springs Reservoir. Pilarcitos Creek is on the eastern flanks of Montara Mountain west of Cahill Ridge and drains to Pilarcitos Reservoir and Stone Dam Reservoir. Water is diverted from Pilarcitos and Stone Dam Reservoirs to the Crystal Springs and San Andreas Reservoir watersheds.

ALAMEDA WATER QUALITY CONDITIONS

- The Alameda watershed water is treated and filtered at the Sunol WTP. The San Antonio Reservoir stores Hetch Hetchy and Calaveras Reservoir waters and stored imported water from the State Water Project for a couple of years during the recent drought.

- Calaveras Reservoir receives only local runoff as inflow, and consequently water quality is relatively consistent. The reservoir stratifies during the late summer and fall. Hypolimnetic aeration has been added to alleviate anoxic conditions and reduce the concentrations of dissolved iron, manganese, and hydrogen sulfide in the raw water. San Antonio exhibits less pronounced seasonal behavior, and the hypolimnion generally remains aerobic during the warm weather months. Water quality in San Antonio Reservoir is more variable, reflecting inputs from Calaveras Reservoir, Hetch Hetchy Aqueduct, and the South Bay Aqueduct.

- *Giardia lamblia* and *Cryptosporidium* were detected in samples collected from the two reservoirs during 1993. In Calaveras Reservoir, counts ranged from 0.3 to 0.5 cysts per 100 liters for *Giardia* and 0.2 to 0.7 oocysts per 100 liters for *Cryptosporidium*. Likewise in San Antonio Reservoir, the monitoring results indicated 0.3 and 0.8 *Giardia* cysts per 100 liters and from 0.3 to 1.2 *Cryptosporidium* oocysts per 100 liters. More than 95 percent of the total coliform tests throughout the distribution system were negative, complying with the Total Coliform Rule.

- Review of time series data for San Antonio Reservoir indicates some evidence of increasing levels in chloride, conductivity, and sodium, likely due to the addition of State Water Project water. Raw water samples have contained sodium levels above the treated water secondary maximum contaminant levels (SMCL) (non-enforcable standards); however there are no data on concentrations subsequent to treatment. Raw water color and pH levels in both Calaveras and San Antonio Reservoirs sometimes exceed the treated water SMCL.

PENINSULA WATER QUALITY CONDITIONS

- The Peninsula watershed stores water from Sunol WTP and the Hetch Hetchy system (in Crystal Springs and San Andreas Reservoirs) which is then blended with local runoff and treated and filtered at the Tracy WTP.

- Crystal Springs and Pilarcitos Reservoirs exhibit seasonal behavior, stratifying in the late summer and fall. The hypolimnion in both reservoirs become anoxic from July to November. San Andreas, on the other hand, is relatively shallow and receives transfers from the other two reservoirs. It remains well-mixed with dissolved oxygen present throughout the water column all year long.

- In 1989, SFWD conducted sampling for *Giardia lamblia* and *Cryptosporidium* at Upper Crystal Springs, Lower Crystal Springs, and San Andreas Reservoirs. *Cryptosporidium* was detected at San Andreas Reservoir. In 1993, SFWD conducted biweekly testing at San Andreas Reservoir which was considered representative of the Peninsula watershed since all water stored in the Peninsula reservoirs is transferred to San Andreas Reservoir prior to treatment. *Giardia* was present in two samples, at 0.3 and 0.5 cysts/100 liters and *Cryptosporidium* was detected in six samples, with concentrations ranging from 0.5 to 2.1 oocysts/100 liters. More than 95 percent of the total coliform samples collected throughout the treated water distribution system were negative, complying with the Total Coliform Rule.

- Raw water samples in all three reservoirs had color readings that exceeded the treated water SMCL. Pilarcitos Reservoir had elevated levels of iron and manganese, exceeding the treated water SMCL for these parameters.

POTENTIAL CONTAMINANT SOURCES WITHIN ALAMEDA WATERSHED

- Table ES-1 presents land uses and activities which occur in the Alameda watershed and groupings of the associated water quality parameters of concern. Changes to land uses which are being planned for by local land use agencies (via General Plans, permits granted, or other steps undertaken) include the development of the Apperson quarry in the San Antonio watershed, the urban encroachment of residential lands upstream of Calaveras Reservoir in Santa Clara County, and the recent considerations for a toll road along Highway 89 near San Antonio Reservoir. The Quantec and Calaveras Test Site industrial facilities adjacent to Calaveras Reservoir were recently closed by SFWD.

- Lands upstream of the reservoirs are of most concern to SFWD followed next by the lands downstream to Sunol. However, recent studies have recommended that SFWD move the Alameda Creek diversion point upstream to a location near the Sunol WTP. This relocation would reduce water quality concerns associated with the nursery, quarry, golf course leases, and other land uses that occur within the Sunol Valley.

TABLE ES-1

POTENTIAL CONTAMINANT SOURCES AND ASSOCIATED WATER QUALITY CONCERNS

PRINCIPAL ACTIVITIES	WATER QUALITY CONCERNS			
	Microorganisms	DBP Precursors/ Nutrients	SOCs/ Pesticides/Metals	Particulates
Both Watersheds				
Vehicle Corridors/Parking			✔	✔
Utility Corridors				
-Natural Gas Pipelines				✔
Recreation	✔	✔		✔
Golf Course		✔	✔	✔
Sanitary Facilities-All Uses	✔	✔	✔	
Wildlife	✔	✔		✔
Natural Resource Management				
-Fire management practices		✔		✔
-Control of particulates		✔		✔
SFWD Operations				
-Cottages	✔	✔	✔	✔
-Boats			✔	✔
Alameda Watershed				
Utility Corridors				
-Petroleum Pipeline			✔	
-Electrical Substation			✔	✔
Residential Land Uses	✔	✔	✔	✔
Livestock Grazing	✔	✔		✔
Nurseries		✔	✔	✔
Quarries			✔	✔
Closed Industrial Facilities			✔	
Natural Resource Management				
-Star Thistle Control		✔	✔	
-Ground Squirrel Control		✔	✔	
SFWD Operations				
-Maintenance Yard			✔	✔
-Treatment Operations				✔
Peninsula Watershed				
Filoli Estate	✔	✔	✔	✔
SFWD Operations				
-Treatment Operations	✔	✔	✔	✔

- Of the existing watershed land uses and activities listed in Table ES-1 and the planned activities described above, the activities of most concern are listed below. Recommendations for managing these activities are provided in Section 10.
    - Quantec and Calaveras Test Site residual contaminants;
    - Calaveras Road and other public roads near Calaveras Reservoir and its tributaries and associated concerns of vehicle spills and runoff, and increased risk of fire and vandalism;
    - Chevron pipeline near San Antonio Reservoir risk of rupture;
    - Livestock pathogens;
    - High clay content of soils;
    - Residential septic systems near waterbodies and increased access on watersheds lands by the public;
    - Planned Apperson Ridge quarry truck traffic and erosion; and
    - New roads and site grading associated with urban development.

- A thorough analysis was conducted to determine water quality vulnerability zones of the Alameda and Peninsula watershed lands; a summary of the Water Quality Vulnerability Zone Analysis can be found in Appendix D of this survey. These zones indicate lands which are not only sources of potential natural contaminants such as high clay content soils, but also are more likely to transport these and introduced contaminants to the waterbodies. Watershed characteristics such as soils, slope, vegetation, and proximity to water/wildlife concentration areas were mapped into a geographic information system (GIS) and analyzed to determine high, medium, and low vulnerability zones.

POTENTIAL CONTAMINANT SOURCES WITHIN PENINSULA WATERSHED

- Table ES-1 presents land uses and activities which occur in the Peninsula watershed and the associated water quality parameters of concern. Planned changes to land uses include the expansion of Highway 92 across Crystal Springs Reservoir and Filoli Estate building, road, and septic system construction activities.

- Of the existing watershed land uses and activities listed in Table ES-1 and the planned activities described above, the activities of most concern are listed below: Recommendations for managing these activities are provided in Section 10.

- Highway 92 vehicle spills and runoff, Interstate 280 major vehicle spills, and increased risk of fire and vandalism associated with both highways;
- Filoli septic systems and buried fuel tanks;
- Risk of fire in watershed;
- Public access trails near San Andreas and Crystal Springs Reservoirs;
- Asbestos fibers from serpentine rock on west side of watershed;
- Crystal Springs Golf Course runoff of nutrients and pesticides;
- Tracy WTP backwash disposal; and
- Skyline Quarry runoff of metals.

WATERSHED CONTROL AND MANAGEMENT PRACTICES

- The SFWD organizational structure as it relates to watershed management and water quality control is described in Section 9 of this survey. The current overall SFWD watershed management and field practices in the Alameda and Peninsula watersheds are improving, but are not always consistent with best management practices (BMPs). Modifications to provide consistent BMPs are being developed. Recommended improvements are provided in Section 10 of this survey and are being developed in further detail as a part of the San Francisco Watershed Management Plan project currently underway.

- Outside agencies with watershed control authority or responsibility towards land uses and activities which may impact water quality within the watersheds are listed and described in Section 9 of this survey. The Regional Water Quality Control Board is a key water quality protection agency due to its policies and regulations pertaining to point and non-point discharges to waterbodies. The Alameda, Santa Clara, and San Mateo County General Plans are the policy, land use regulation, and program tools best utilized in controlling lands not owned by SFWD. Recommendations for working with these agencies are provided in Section 10.

RECOMMENDED CORRECTIVE ACTIONS

- Due to the ever increasing regulatory emphasis on raw water quality and corresponding treatment requirements, and the drinking water industry's increasing knowledge of contaminants in source waters and suspected carcinogens formed during the disinfection process, recommendations have been developed here to strengthen the protection of source waters. The recommendations are grouped by the following subjects: water quality

monitoring, watershed control and management practices, interjurisdictional coordination, and public education.

- Water quality monitoring recommendations are focused on new watershed monitoring programs and the augmentation of existing programs, groundwater characterization, and reservoir management. These recommendations should be defined further based on particular geographic and seasonal conditions and water quality control purposes and implemented at every opportunity. Implementation will increase SFWD's knowledge of contaminant sources within the watersheds and ensure the availability of data needed to determine baseline conditions, detect changes in the quality of raw waters, and determine the effectiveness of future management controls.

- Watershed control and management practices are needed to minimize the risks to water quality associated with land uses and activities. Recommendations are provided to minimize impacts from construction and maintenance activities and to better manage SFWD and leasee activities on watershed lands.

- Interjurisdictional coordination is important to open lines of communication with other agencies, coordinate responses to water quality emergencies, and instill the value of water quality protection within and adjacent to the watersheds. Recommendations are provided for working with agencies in designating watershed lands for special controls, reviewing land use proposals, coordinating specific activities, and addressing emergency response planning.

- Public education materials should be developed on the importance of water supplies, activities that affect water quality, and water quality protection measures. It is recommended that these materials be targeted and distributed to trail users, residential and commercial neighbors, and local and regional governments, and along transportation corridors.

SECTION 1

INTRODUCTION

STUDY PURPOSE AND SCOPE

The federal Surface Water Treatment Rule (SWTR) approved by Congress in 1989 includes a recommendation for all surface water systems to conduct watershed control plans. As the primacy agency for the implementation of the SWTR, the California Department of Health Services (DHS) specifies that all surface water systems prepare a watershed sanitary survey (WSS) of their water supply watersheds by January 1, 1996 and update it every five years.

Because Article 7, Section 64665, of the state's version of the SWTR (Title 22 California Code of Regulations) provides minimal guidance on the procedure for conducting a WSS and the contents the report must contain, a guidance manual was developed by members of the Watershed Sanitary Survey Guidance Manual Work Group, a subgroup of the Cal-Nevada American Water Works Association Source Water Quality Committee. The guidance manual was released in April of 1994. Montgomery Watson was involved with the manual development and therefore was able to use the draft document to define the scope of this report.

The WSS has been prepared as a part of the San Francisco Watershed Management Plan project which began in mid-1992 and is expected to continue through 1995. Watershed management plans are being developed for 23,000 acres of the Peninsula watershed (within San Mateo County) and 40,000 acres within the Alameda watershed (Alameda and Santa Clara counties), lands owned by San Francisco. These lands store and provide water to San Francisco, as well as portions of San Mateo, Santa Clara, and Alameda counties. As described in Section Two, the water supply system also includes the Tuolumne River watershed and the lands within the City and County of San Francisco (City). The Tuolumne River system was addressed in the Hetch Hetchy WSS which was prepared and submitted to DHS. Another separate but important analysis is being conducted on the Alameda Creek to determine the feasibility of improving fish habitat. This report will be available to DHS in 1995.

WATERSHED SANITARY SURVEY REQUIREMENTS

Title 22 of the California Code of Regulations requires that the WSS and report include a physical and hydrogeological description of the watershed, a summary of source water quality monitoring data, a description of activities and sources of contamination, a description of

watershed control and management practices, an evaluation of the system's ability to meet requirements of Title 22 - Chapter 17: Surface Water Filtration and Disinfection Treatment, and recommendations for corrective actions. Future survey updates must include a description of any significant changes that have occurred since the last survey which could affect the quality of the source water.

SURVEY METHODS

As a part of the San Francisco Watershed Management Plan program tasks, Montgomery Watson and its subconsultants conducted a survey of potential contaminant sources and an analysis of water quality conditions within the Alameda and Peninsula watersheds. Aerial photographs, USGS topographic maps, land use maps, water quality data, and numerous reports were reviewed, the watersheds were surveyed by automobile, and San Francisco Water Department (SFWD) staff and outside agencies were interviewed. Data collected and analyzed for the SFWD Watershed Management Plans were used as much as possible. In addition, Montgomery Watson conducted an analysis of the natural physical conditions of the watershed lands for the potential to impact drinking water quality parameters. This analysis was conducted for a different project purpose but the results were utilized for the survey, when appropriate, to provide the most thorough description of potential contaminant sources and watershed vulnerability zones.

ABBREVIATIONS AND CONVERSIONS

To conserve space and improve readability, the following standard abbreviations have been used in this report.

ac-ft/yr	acre-feet per year
ACWD	Alameda County Water District
BAWUA	Bay Area Water Users Association - wholesale contractors of SFWD
Bay	San Francisco Bay
BMPs	Best Management Practices
CCWD	Coastside County Water District
City	City and County of San Francisco
cfs	cubic feet per second
D/DBPs	Disinfection/Disinfection By-Products
Delta	Sacramento River and San Joaquin River Delta
DHS	California Department of Health Services
DWPL	Drinking Water Priority List
DWR	California Department of Water Resources

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EBRPD	East Bay Regional Park District
EPA	U.S. Environmental Protection Agency
gpd	gallons per day
gpd/ft	gallons per day per foot
gpm	gallons per minute
gpm/sf	gallons per minute per square foot
HPC	Heterotrophic Plate Count
MCL	maximum contaminant level - enforceable standard
MCLG	maximum contaminant level goal - health goal, nonenforceable
mgal	million gallons
mgd	million gallons per day
mg/L	milligram/liter, equivalent to 1 part per million
MID	Modesto Irrigation District
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Unit (standard turbidity measurement)
Peninsula	San Francisco Peninsula
PG&E	Pacific Gas and Electric Company
RWQCB	Regional Water Quality Control Board
SBA	South Bay Aqueduct
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act of 1974
SFPUC	San Francisco Public Utilities Commission
SFWD	San Francisco Water Department
SMCL	Secondary Maximum Contaminant Levels
SOC	synthetic organic chemicals
sq. mi.	square mile
SWRCB	State Water Resources Control Board
SWTR	Surface Water Treatment Rule - adopted by EPA in 1989
TCR	Total Coliform Rule
TDS	total dissolved solids
THMs	trihalomethanes
TID	Turlock Irrigation District
USGS	U.S. Geological Survey
VOCs	volatile organic chemicals
WQPS	Water Quality Planning Study prepared for SFWD
WTP	water treatment plant or filter plant

Generally speaking, water flow and volume units in the United States are either in gallons, cubic feet per second, or acre-feet, except for water quality parameters which are in metric units. Acre-feet is used in this report for raw water storage; mgd and cfs are used for conveyance; mgal for

treated water storage. Conversion factors of commonly used water units are provided here so that only one set of units is utilized each time in this report.

1 ac-ft	=	325,900 gallons
1,000 ac-ft/yr	=	0.8927 mgd
1 mgal	=	3.07 ac-ft
1 mgd	=	1,122 ac-ft/yr
1,000 gpm	=	2.23 cfs
1 cfs	=	646,360 gpd

SECTION 2

WATER SUPPLY, CONVEYANCE, AND TREATMENT SYSTEMS

A description of the SFWD water supply, storage, transmission, and treatment facilities is provided here. Although the WSS is focused on the local watersheds, an overview of the entire system is provided to aid in the understanding of this complex system and how the local watershed facilities are integrated into the system. The local watershed facilities are described in more detail than the Hetch Hetchy facilities and the facilities within the city limits.

OVERVIEW OF SAN FRANCISCO WATER SYSTEM

The San Francisco water system was originally conceived in the late 19th century and much of it constructed during the early part of the 20th century. The system obtains water primarily from three sources: Tuolumne River via the Hetch Hetchy system in the Sierra Nevada mountains, local runoff in the Calaveras and San Antonio reservoir watersheds in the eastern San Francisco Bay Area, and local runoff in the Crystal Springs, San Andreas, and Pilarcitos reservoir watersheds on the San Francisco Peninsula. In addition, San Francisco obtains some water from groundwater basins in San Francisco, Pleasanton, and the Sunol Valley. Approximately 80 to 85 percent of the potable supply to SFWD customers is provided by the Hetch Hetchy watershed.

Overview

A schematic of the overall water system is presented in Figure 2-1. Water is conveyed to the San Francisco Bay Area from the Hetch Hetchy system across the San Joaquin Valley through a series of aqueducts and tunnels to Alameda County near the community of Sunol. Some of the Hetch Hetchy water is stored in San Antonio Reservoir; the remainder continues to flow through the Irvington Tunnel and the Bay Division Pipelines.

The local runoff from Calaveras and San Antonio reservoirs is treated at the Sunol Valley Filter Plant (WTP) and combined with the Hetch Hetchy water. This water is then conveyed across the San Francisco Bay (Bay) and distributed to wholesale customers along the way. Part of this water is stored in Peninsula reservoirs where it is blended with local runoff; the remainder is conveyed to wholesale customers along the Peninsula and individual customers within the City. The water stored in the Peninsula reservoirs is treated at the Harry W. Tracy Filter Plant (Tracy WTP). This water continues on to San Francisco and provides a potable supply along the way.

OVERVIEW OF SAN FRANCISCO WATER SYSTEM

FIGURE 2-1

MONTGOMERY WATSON

The primary reservoirs in the system are listed in Table 2-1 along with the catchment areas and the reservoir storage capacities. SFWD owns most of the lands within each Bay Area catchment area; the Sierra catchment areas are within Stanislaus National Forest and Yosemite National Park. The catchment areas are similar to the total watershed areas except for Calaveras Reservoir; its watershed extends further south beyond SFWD properties. It should be noted that the Alameda Creek watershed (which includes the catchment areas of Calaveras and San Antonio Reservoirs) is 633 square miles (sq. mi.). Using Sunol Dam as the easternmost point, this watershed extends as far south as Mount Hamilton, as far east as the Altamont Pass, and almost as far north as Mount Diablo.

TABLE 2-1

SAN FRANCISCO WATER DEPARTMENT STORAGE RESERVOIRS

Primary Reservoirs	Maximum Capacity acre-feet	Maximum Capacity mgal	Catchment sq. mi.
Hetch Hetchy Watershed			
Cherry Valley	268,800	87,600	114
Eleanor	27,100	8,830	79
Hetch Hetchy	360,400	117,400	459
Alameda Watershed			
Calaveras	96,900	31,550	135(1)
San Antonio	50,500	16,500	39.7
Peninsula Watershed			
Crystal Springs	58,400	19,020	24.6(2)
Pilarcitos	3,100	1,010	4.3(3)
San Andreas	19,000	6,190	6.9(4)

Notes:

(1) Includes 35 sq. mi. of Upper Alameda Creek catchment area.
(2) Includes 2.1 sq. mi. of Stone Dam catchment area.
(3) Does not include 0.6 sq. mi. from Pilarcitos side flume no longer in service.
(4) Includes 2.5 sq. mi. of catchment area along San Mateo Creek.

The SFWD provides water to approximately 2.15 million people, and was approaching an average daily consumption of approximately 290 mgal before the recent drought. Approximately 80 mgd, or 40 percent, is currently utilized within the City and approximately 130 mgd, or 60

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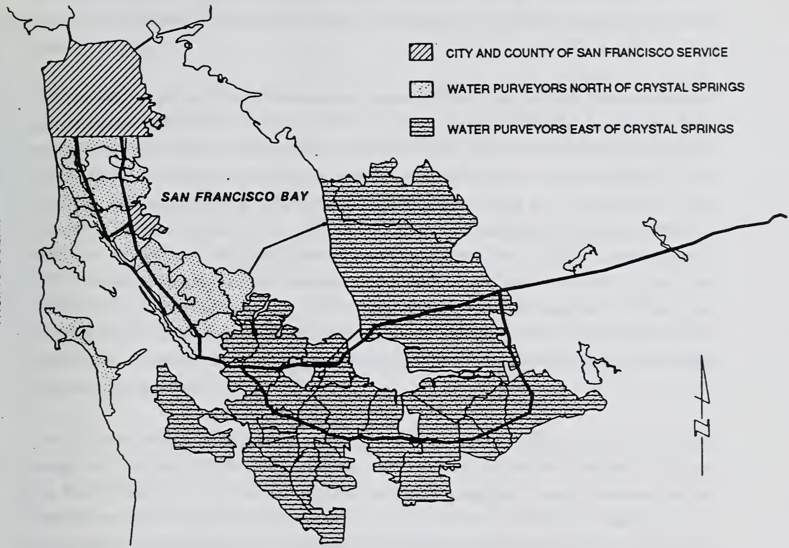
percent, is currently provided to 30 wholesale water purveyors along the southern half of the San Francisco Bay, as presented in Figure 2-2. A reduced consumption from predrought conditions reflects a rationing restriction imposed on the consumers. The 30 water agencies which purchase wholesale potable water from San Francisco, together called the Bay Area Water Users Association (BAWUA), deliver it directly to the consumers. The members of the BAWUA are listed in Figure 2-2.

Hetch Hetchy System

Although the conveyance and storage facilities of the Hetch Hetchy system are not directly pertinent to this WSS (a separate WSS has been prepared by SFWD for the Hetch Hetchy watershed system), the following overview is provided for clarity. Only the primary facilities are presented in Figure 2-1. The lime treatment and chlorine stations are located within the Hetch Hetchy system are discussed later under treatment facilities but are located in Figure 2-1.

Supply and Storage. The Tuolumne River, with its source in several glaciers on the 13,000 feet high Mount Lyell and Mount Dana, drains 713 square miles of watershed in rugged granite mountains which slope west from the Sierra Nevada crest. Over 90 percent of the watershed is at elevations above 6,000 feet. The Tuolumne River flows through the northern reaches of Yosemite National Park and through the Stanislaus National Forest. The river continues through the Sierra Nevada foothills and enters the San Joaquin Valley near Modesto. The Tuolumne River flows into the San Joaquin River which drains to the Bay.

In 1902, an appropriation of flow in the Tuolumne River was made for San Francisco in accordance with California State law. San Francisco obtained water rights to the upper reaches of the Tuolumne River of approximately 448,800 ac-ft/yr and began planning for the development of a water system from Hetch Hetchy Valley, Lake Eleanor, and Cherry Creek Canyon. Between 1902 and 1913 the City attempted to obtain federal approvals to develop a water system in the Sierras. These efforts were opposed by the Spring Valley Water Company, and Modesto and Turlock Irrigation Districts (MID and TID), the fledgling environmental movement and the changing philosophies of different administrations' Interior Department appointees. These efforts culminated in the passage of the Raker Act in 1913; this was the act of Congress necessary for San Francisco to develop water and power facilities on federal park and forest lands. Although the City holds its water rights under California law, the Raker Act has specific restrictions governing its supply. The Act requires San Francisco to recognize the prior rights of the MID and TID to receive water they can beneficially use - up to specified amounts of



Alameda County Water District	City of Menlo Park
Belmont County Water District	City of Millbrae
City of Brisbane	City of Milpitas
City of Burlingame	City of Mt. View
- Bear Gulch District	North Coast County Water District
- San Carlos District	City of Palo Alto
- San Mateo District	Purissima Hills Water District
- South San Francisco District	City of Redwood City
Coastside County Water District	City of San Bruno
Cordilleras Mutual Water Association	City of San Jose
City of Daly City	San Mateo CWD No. 3
East Palo Alto CWD	City of Santa Clara
Estero MID	Skyline County Water District
Guadalupe Valley MID	Stanford University
City of Hayward	City of Sunnyvale
Town of Hillsborough	Westborough County Water District
Los Trancos County Water District	

MEMBERS OF BAY AREA WATER USERS ASSOCIATION

FIGURE 2-2

the natural daily flow - for direct use and storage. The Raker Act also requires that the City not divert any more Hetch Hetchy water than that necessary for beneficial domestic and other municipal purposes.

Work by the City on the Hetch Hetchy system began in 1914. Lake Eleanor, with a capacity of approximately 27,000 ac-ft on a branch of Cherry Creek, was converted from a small glacial lake into a reservoir through the construction of Eleanor Dam. This was the first project and was constructed to generate hydroelectric power for the construction of O'Shaughnessy Dam. Following the completion of Lake Eleanor, construction started on O'Shaughnessy Dam, resulting in Hetch Hetchy Reservoir. O'Shaughnessy Dam was later raised in 1938 resulting in a capacity of 360,400 ac-ft for Hetch Hetchy Reservoir. Cherry Valley Dam was constructed by 1956, forming Cherry Lake (later referred to as Lake Lloyd Reservoir) with a capacity of 268,800 ac-ft. A tunnel between Lakes Cherry and Eleanor was then constructed. Water from Cherry Lake and Lake Eleanor is used for both power generation and to meet the Raker Act requirements in a storage exchange agreement with MID and TID. The catchment areas of these three reservoirs are listed in Table 2-1.

The City purchased 570,000 ac-ft of operational storage plus 170,000 ac-ft of flood control storage out of the total storage being provided to MID and TID by the New Don Pedro Dam and Don Pedro Reservoir. This reservoir provides exchange storage only, as all diversions for San Francisco are made from Hetch Hetchy Reservoir. However, after construction finished in 1971, the Don Pedro Reservoir significantly increased the amount of water which the City could divert from the Tuolumne River during non-drought years.

Transmission to the Alameda East Portal. Hetch Hetchy Reservoir water generates power through the 11 mile Canyon Power Tunnel which terminates at Early Intake, a small diversion facility for Mountain Tunnel. The Hetch Hetchy water is diverted from Early Intake through Mountain Tunnel and travels 19 miles to Priest Reservoir. Priest Reservoir has a capacity of 1,055 ac-ft and was constructed as a regulating reservoir to receive water used for power generation and then convey it to Moccasin Reservoir. Moccasin Reservoir, with a capacity of 505 ac-ft, was built as a re-regulating reservoir to balance the electrical generation flow needs with the Hetch Hetchy Aqueduct uniform flow needs. The hydroelectric facilities along this transmission route are not discussed in this memorandum. The revenue generated by the powerhouse pays for all Hetch Hetchy operations, maintenance, and improvements; it finances the operation of the Municipal Railway electrical distribution network; and it supplies municipal power in San Francisco.

From Moccasin Reservoir, the water is conveyed 16 miles from the Moccasin Portal through tunnels and pipelines (the Foothill Tunnel) to the Oakdale Portal, then 47 miles through the three parallel San Joaquin Pipelines, across the San Joaquin Valley to the Tesla Portal located on the eastern side of the Coast Range Mountains. The San Joaquin Pipelines Nos. 1, 2, and 3, were completed in 1932, 1953, and 1968 respectively. From the Tesla Portal, the water continues 25 miles through the Coast Range Tunnel to the Alameda East Portal, located approximately three miles south of the community of Sunol.

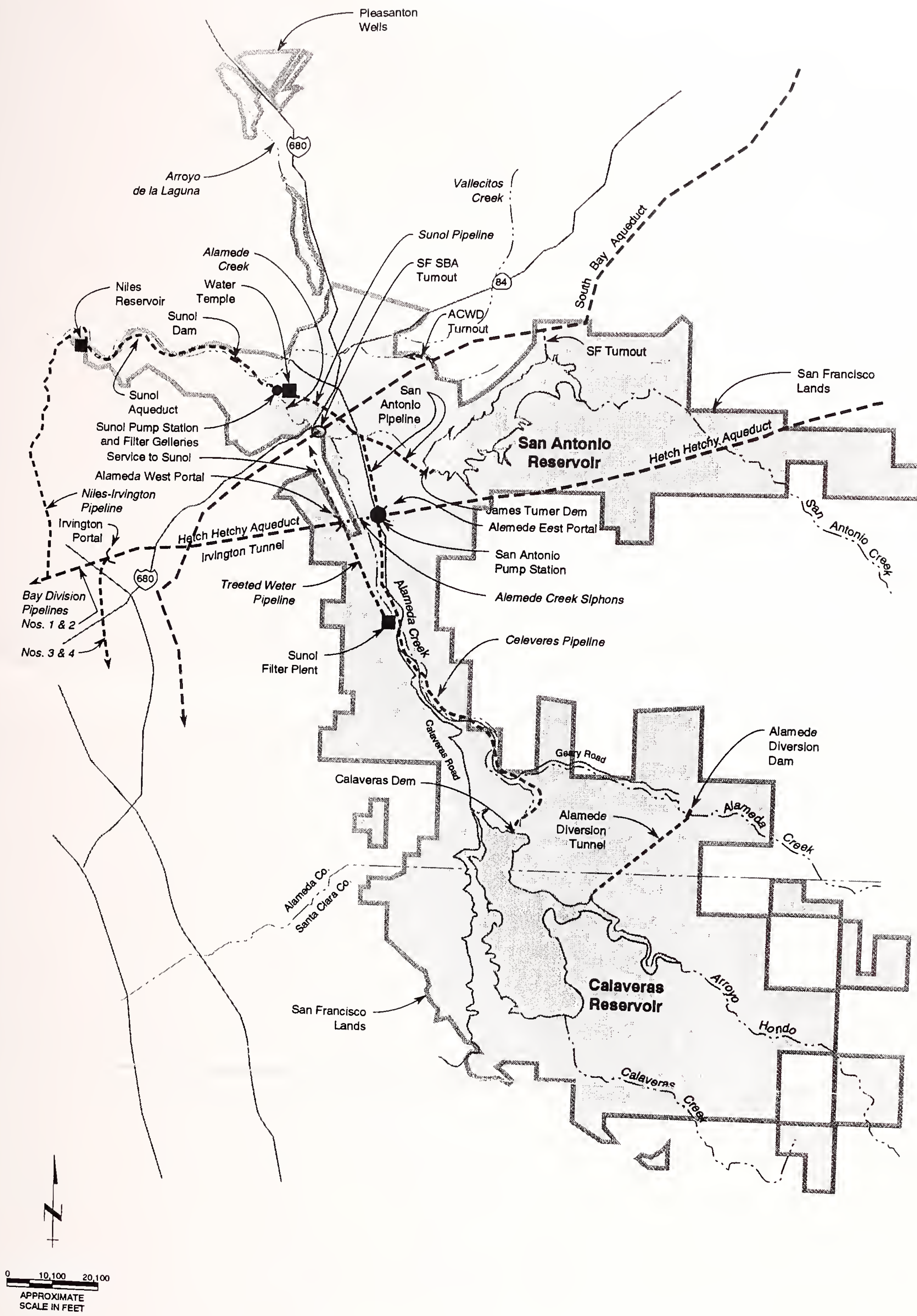
Normally, Lake Eleanor water is diverted to Cherry Lake and these waters are conveyed through the Cherry Power Tunnel to the Holm Power House. The waters are then released into Cherry Creek which flows to the Tuolumne River to meet the requirements of MID and TID at Don Pedro Reservoir. If needed to supplement the Hetch Hetchy supply during an emergency, water from Lake Eleanor and Cherry Reservoir can be conveyed through Cherry Power Tunnel to other transmission facilities which connect with Early Intake, however, this diversion to the Hetch Hetchy system is not a normal operating procedure. If necessary, Cherry Lake water can be pumped back to Lake Eleanor.

ALAMEDA WATERSHED SYSTEM

The two Alameda County reservoirs, Calaveras and San Antonio, are discussed here along with the transmission facilities between the reservoirs, the Sunol WTP (described in more detail later), and other facilities within Sunol Valley, ending with the Irvington Portal. Figure 2-3 illustrates the Alameda System. A brief discussion of the Alameda County Water District (ACWD) is provided because of its use of waters from Alameda Creek and its tributaries within the Alameda watershed.

Calaveras Reservoir

Construction was started by the Spring Valley Water Company on the original Calaveras Dam in early 1913. A portion of the upstream face of the dam failed in 1918. The reconstructed dam was completed in 1925 over the Calaveras Creek, just below its confluence with Arroyo Hondo and upstream of its confluence with Alameda Creek. At the time of construction, the 215 foot earth filled dam was the highest in the world. Since Alameda Creek does not drain into Calaveras Reservoir, the Alameda diversion dam and tunnel were constructed following the



ALAMEDA SYSTEM

FIGURE 2-3

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completion of Calaveras Dam to divert Alameda Creek flows into the reservoir. This facility was completed in 1931 and is located two miles northeast of the reservoir along Alameda Creek.

Calaveras Reservoir has a capacity of 96,900 ac-ft. The watershed for Arroyo Hondo and Calaveras Creek is approximately 100 square miles, plus 35 square miles for the upper Alameda Creek watershed upstream of the diversion dam. 128 square miles of the 135 square miles of watershed lands are within Santa Clara County with the remainder in Alameda County.

San Antonio Reservoir

James H. Turner Dam and San Antonio Reservoir are the latest major additions to the San Francisco system, having been completed in 1965. The dam is across La Costa Creek, also referred to as San Antonio Creek, which is a tributary to Alameda Creek, downstream of the confluence of Alameda and Calaveras creeks. The reservoir has a capacity of 50,500 ac-ft and collects runoff from a watershed of 40 sq. mi. It is used to store Hetch Hetchy water, the South Bay Aqueduct emergency water (discussed below), Calaveras Reservoir surplus water (via the Calaveras Pipeline), as well as local runoff. In addition, facilities are available to pump Alameda Creek/groundwater to San Antonio Reservoir from the Sunol Filter Galleries via the Sunol pump station and pipeline and the San Antonio pipeline.

Pleasanton Wells

Approximately four miles north of Sunol, there are 17 wells located in the Pleasanton Well Field, which is on City property straddling Highway 680 in Pleasanton. This groundwater supply was first utilized in 1898. The Pleasanton/Sunol pipeline, a 30-inch pipeline, was constructed in 1909 to convey groundwater to the Sunol Water Temple. This pipeline was severed in the early 1960's. The remaining system is currently used to collect well water from the SFWD's remaining Pleasanton lands and conveyed to Castlewood Country Club's reservoir.

Sunol Valley Groundwater

The Sunol Valley, south of the Pleasanton wells, is a gravel filled depression of about 1,300 acres at the upper entrance to Niles Canyon. The Alameda Creek drainage area of some 600 square miles includes waters from the catchment area of Arroyo de la Laguna (which includes Arroyo Mocho and Arroyo Del Valle) to the north and northeast, Alameda Creek and Calaveras Creek drainage areas to the south, local groundwaters, and surface waters imported from the

State Water Project via the South Bay Aqueduct for the ACWD as discussed below. Alameda Creek flows through Sunol Valley (that flow which is not diverted into the reservoirs), through the Niles Canyon, then becomes a flood control channel to the Bay. The water in Sunol Valley is surface water directly conveyed through the creeks, and surface and ground waters which have infiltrated into the porous, gravelly valley soils. Since the Sunol Valley groundwater supply is heavily influenced by the surface water flowing from Alameda Creek, it is subject to surface water drinking regulations which are more stringent than groundwater regulations.

Sunol Dam, a 28 foot high concrete structure, was constructed in 1899 and is located on Alameda Creek about one mile west of Sunol. It is usually submerged but it holds back the creek flow to increase the recharge of water into the groundwater aquifer. In addition to Sunol Dam, filter beds, or groundwater recharge basins, were developed around 1900 near the Sunol Water Temple to increase the infiltration of rainfall.

The water in Sunol Valley percolates through the gravel beds and is collected in underground 36-inch perforated concrete pipes and conveyed through screened brass pipes to a concrete tunnel, called Filter Galleries. The Filter Galleries are approximately 9,000 feet long and parallel Alameda Creek. They begin at both the Sunol Dam and a point just west of Highway 680 and converge at the Sunol Water Temple. The Sunol Pump Station is located next to the Water Temple and when used, can pump groundwater from the Filter Galleries through the 36-inch Sunol Pipeline to the San Antonio Pipeline where it can be conveyed to San Antonio Reservoir or to the Sunol WTP. The water can also be conveyed through the Sunol Aqueduct to Niles Reservoir.

The Sunol Aqueduct was constructed in 1900 first as a flume, replaced by a concrete box in 1923, to supply water from the Filter Galleries to the Peninsula via Niles Reservoir within Niles Canyon. The aqueduct alignment is adjacent to and within the Alameda Creek bed and terminates at the Niles Reservoir in Fremont. It is now used to supply nonpotable water to several customers in the canyon, but its use is scheduled to be terminated at the end of 1994. From Niles Reservoir, the Niles-Irvington 44-inch pipeline, which can reverse the direction of flow, continues along an easement in railroad company right-of-way and travels south to its terminus at the Bay Division Pipelines Nos. 1 and 2 at the Irvington Pump Station. The Sunol Aqueduct and the Niles-Irvington Pipeline have been abandoned and are being decommissioned.

South Bay Aqueduct Supply

The SFWD purchased State water from the emergency water bank during the latest drought to augment its surface supplies. This water is conveyed from the State storage facilities north of the Sacramento River-San Joaquin River Delta (Delta), through the Sacramento River and Delta rivers, to the Clifton Court Forebay, a regulating reservoir. It is then pumped through the Banks Pumping Plant near the City of Tracy to Bethany Reservoir.

The water is pumped into the South Bay Aqueduct (SBA), a 43-mile system of pipelines, canals, and tunnels which convey State water to the three primary SBA water contractors: the ACWD, the Santa Clara Valley Water District, and the Alameda County Flood Control and Water Conservation District - Zone 7, all located within Alameda and Santa Clara counties. The Aqueduct winds its way from Bethany Reservoir south around the Livermore Valley with a connection to Del Valle Reservoir (a State storage facility), then across the northern end of San Antonio Reservoir. It continues across Sunol Valley parallel to Highway 680 and into Fremont, Milpitas, then terminates in a storage tank in San Jose.

There is one ACWD turnout for SBA water within the Alameda watershed. It is north of San Antonio Reservoir at Vallecitos Creek. Vallecitos Creek is a tributary of the Arroyo de la Laguna which crosses Sunol Valley to its junction with Alameda Creek and continues through Alameda Creek in Niles Canyon to the ACWD groundwater recharge facilities over the Niles Cone aquifer. Because of another turnout at ACWD's new WTP, when it increases its production, less water will be conveyed from the SBA through Sunol Valley via Alameda Creek.

The State also delivers water to SFWD through the SBA on an interim or short-term basis. When San Francisco requests water from the State emergency water bank, it is conveyed through the SBA to a turnout at the north end of San Antonio Reservoir. This turnout conveys the water through a pipe to the outlet located along a small tributary which drains into the San Antonio Reservoir. There was an emergency, drought-related SFWD turnout near where the SBA crosses Alameda Creek. A short segment of pipe conveyed the emergency water to the Sunol pipeline; the SBA water has enough pressure to flow to the Sunol WTP without being pumped. This emergency SBA turnout was removed.

Transmission to the Irvington Portal

From the Alameda East Portal, Hetch Hetchy water is transported 3,000 feet across the Sunol Valley in three parallel siphons under Alameda Creek to the Alameda West Portal. The Alameda West Portal is the entrance to the Irvington Tunnel, a segment of the Hetch Hetchy Aqueduct. Described here is the transfer of water from the Hetch Hetchy Aqueduct into the Alameda system and back into the aqueduct.

Hetch Hetchy water can be transferred from the Alameda Creek Siphon No. 3 into San Antonio Reservoir via the San Antonio Pump Station and the 60-inch San Antonio Pipeline. Hetch Hetchy water can be conveyed to the Sunol WTP through the Calaveras Pipeline via the San Antonio Pump Station, which has a capacity of 160 mgd, but cannot be transferred to Calaveras Reservoir due to its higher elevation. The Calavera Pipeline is also used to convey water by gravity from the Calaveras Reservoir outlet tower to San Antonio Reservoir. This pipeline is located parallel to Alameda Creek with several creek crossings.

All of the water from San Antonio and Calaveras Reservoirs is treated at the Sunol WTP. The San Antonio Reservoir can feed water by gravity into the Sunol plant when the water in that reservoir is at a very high elevation, otherwise it must be pumped through the San Antonio Pump Station. Water from the Calaveras Reservoir flows by gravity to the Sunol WTP. From the Sunol WTP, a 78-inch pipeline, parallel to Alameda Creek on the west bank, conveys treated water 1.7 miles to Alameda Creek Siphons Nos. 2 and 3 where it is blended with the Hetch Hetchy aqueduct water. The three siphons have a capacity of 67, 134, and 152 mgd. The community of Sunol is provided drinking water from the Sunol WTP and the Hetch Hetchy Aqueduct via connections to the Alameda Creek Siphons Nos. 1 and 2.

The Calaveras pipeline provides operational flexibility by allowing water to be conveyed quickly from Calaveras Reservoir or San Antonio Reservoir to the Sunol WTP. This pipeline provides redundancy in the system in the event of a Hetch Hetchy aqueduct outage in which case the reservoir waters can be utilized up to the 160 mgd capacity of Sunol WTP.

Alameda System Operations

During normal weather years, the desired operation of the Alameda reservoirs is to keep the storage low enough on December 1 of each year to capture the average year runoff. June 1 is

the target date for a full reservoir. The Calaveras Reservoir fills entirely from local runoff and is usually full by April during average weather years.

Aeration facilities have been constructed in Calaveras Reservoir to pump air to the zones of stagnation created at the bottom of this deep reservoir. When in operation, the aeration facilities will inject air to increase dissolved oxygen which has been depleted due to decaying organic sediments.

BAY DIVISION PIPELINES

Hetch Hetchy and Sunol WTP blended water is conveyed from the Alameda West Portal through the Irvington Tunnel to the four Bay Division Pipelines. Bay Division No. 1 and No. 2 cross under the Bay to the Peninsula while Bay Division No. 3 and No. 4 skirt the southern end of the Bay to the Peninsula. The BAWUA members between the Irvington Portal at the City of Hayward and the Pulgas Tunnel on the Peninsula are supplied water from the Bay Division Pipelines.

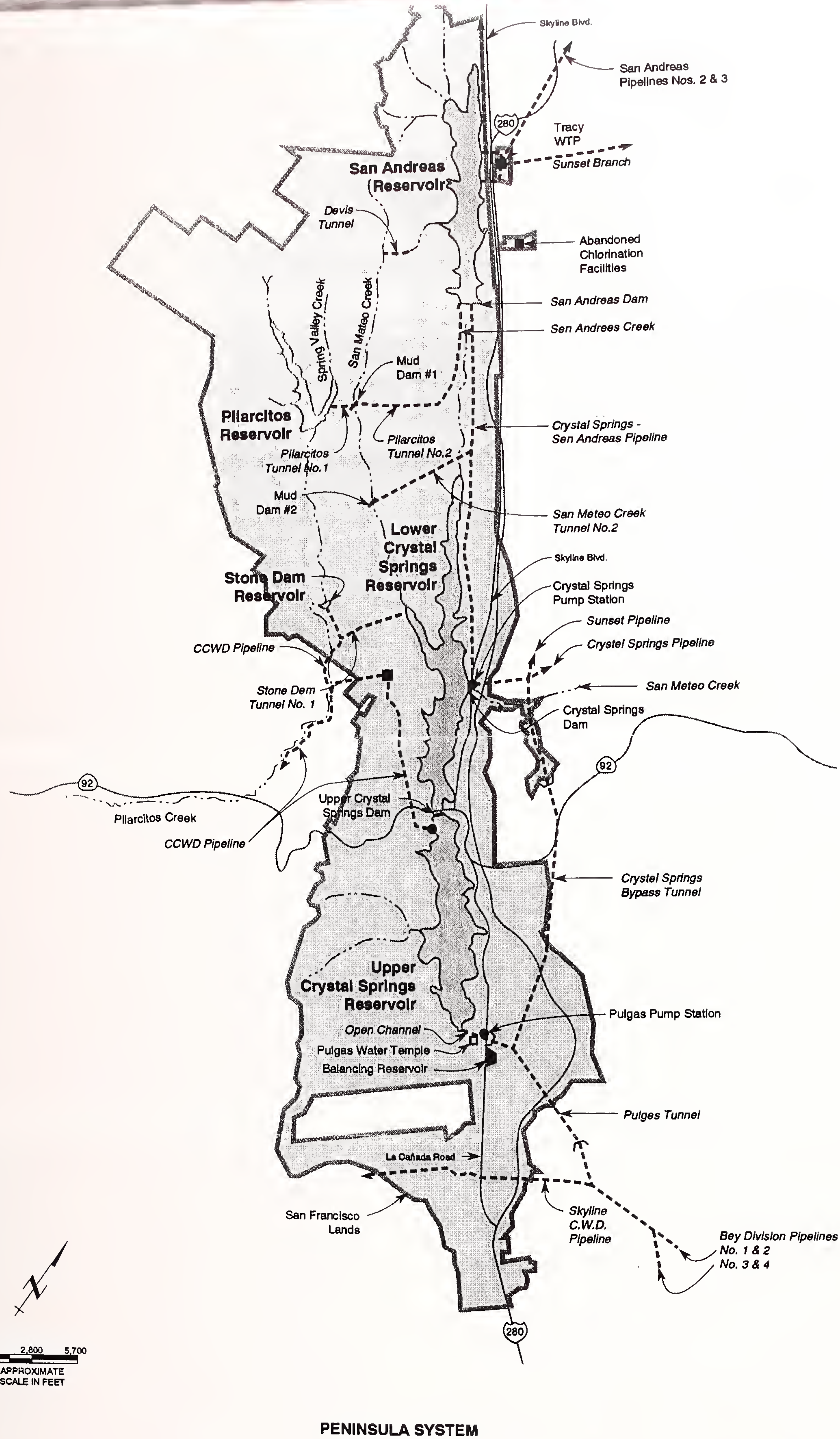
Meters are located on each pipeline west of the Irvington Portal and east of the Pulgas Tunnel to enable the operators at the Sunol WTP to react to system demands along the Bay Division Pipelines. The Bay Division Pipelines join at the Pulgas Tunnel.

PENINSULA WATERSHED SYSTEM

Most of the water conveyed through the Bay Division Pipelines to the Peninsula continues north along the Peninsula to the City and is distributed along the way. The remaining water from the Bay Division Pipelines is diverted through the Pulgas Tunnel and stored in Crystal Springs Reservoir (and San Andreas Reservoir) and is treated at the Tracy WTP. Described here is the Peninsula system starting at the Pulgas Tunnel. This description also includes the Pilarcitos watershed. Figure 2-4 illustrates the Peninsula system.

Pilarcitos Reservoir and Conveyance Facilities

The SFWD owns 23,000 acres of watershed lands east of Montara Mountain. San Francisco has water rights to water in the upper reaches of Pilarcitos Creek. The SFWD utilizes most of this supply to provide water to the Coastside County Water District (CCWD), which serves the Half Moon Bay area. The SFWD also has riparian water rights to the lower reaches of Pilarcitos



PENINSULA SYSTEM

FIGURE 2-4

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MONTGOMERY WATSON

Creek and other coastal tributaries. The Pilarcitos Reservoir is important to SFWD because it provides an emergency gravity flow supply to San Andreas and Crystal Springs Reservoirs.

In 1864, the Spring Valley Water Company completed a dam impounding the waters of the west branch of Pilarcitos Creek and through a system of flumes and pipes, brought the water 32 miles to Laguna Honda Reservoir in San Francisco to augment its supply from local wells and springs. A new Pilarcitos Dam was constructed on the east and west branches of Pilarcitos Creek in 1866 which was then raised slightly in 1874; the main Pilarcitos Dam caused the inundation of the original dam. Pilarcitos Reservoir has a catchment area of 3.8 square miles and a capacity of 3,100 ac-ft. Heavy rainfall exceeding 40 inches a year can be expected in this watershed. The storage in Pilarcitos Reservoir is limited and needs to remain high in order to meet the water demands of CCWD and potential emergencies in San Francisco.

During times of surplus runoff, water is diverted by gravity from the east side of Pilarcitos Reservoir through the Pilarcitos Tunnel No. 1 to San Mateo Creek. Here the upper San Mateo Creek waters and the Pilarcitos Reservoir diversions are either conveyed through the Pilarcitos Tunnel No. 2 to San Andreas Reservoir or flow down San Mateo Creek to Crystal Springs Reservoir.

Water is released for CCWD from Pilarcitos Lake to Pilarcitos Creek which conveys it to Stone Dam Reservoir. Stone Dam was built around 1871 and is a diversion dam located two miles downstream of Pilarcitos Dam. It has a catchment area of 2.1 square miles and has a storage capacity of 15 ac-ft.

During times of surplus precipitation this lower Pilarcitos Creek runoff is diverted from the inlet at the reservoir through Stone Dam Tunnel No. 1 to San Mateo Creek then into Crystal Springs Reservoir. The system originally had a series of flumes and aqueducts from the outlet of Stone Dam Tunnel No. 1 to San Andreas Reservoir, but these facilities are abandoned. Diversions for CCWD are made prior to Stone Dam Tunnel No. 1. This CCWD pipeline is connected to a new CCWD pipeline which conveys water pumped from Upper Crystal Springs Reservoir west to the CCWD's WTP. This new pipeline allows CCWD to obtain water from either the Pilarcitos system or from Crystal Springs Reservoir.

Crystal Springs Reservoir

The Upper Crystal Springs Reservoir was formed after the construction of the Upper Crystal Springs Dam in 1877. Lower Crystal Springs Reservoir was formed in 1890 after the Crystal Springs Dam was placed on San Mateo Creek below the confluence of its main branches. The original outlet from the Upper Reservoir was damaged during the 1906 earthquake; 20 feet of pipeline were fractured by a lateral earth movement of 5.5 feet. The Upper Dam no longer separates the lakes into two water bodies but is used as support for the Highway 92 roadbed with a culvert underneath; the resulting Crystal Springs Reservoir now has unregulated flow between the upper and lower reservoirs.

The newer (1890) Crystal Springs Dam is an arched dam built of interlocking concrete blocks. Concrete was needed because there was no supply of high quality rock proximate to the site, and a very strong and high dam was needed. Blocks were utilized because concrete had a tendency to shrink and crack when pored and set in large masses. This dam is designated as a California Historic Civil Engineering landmark because of the interlocking block design; it is also a marvel because it is as structurally sound today as the day it was completed, surviving the 1906 earthquake along the San Andreas fault just 400 feet to the west. Skyline Boulevard was later constructed over Crystal Springs Dam. The Crystal Springs Reservoir has a capacity of 69,320 ac-ft but is operated at 58,400 ac-ft due to dam safety requirements. The catchment area is 22.5 square miles.

San Andreas Reservoir

The San Andreas Reservoir was created on San Andreas Creek in 1870 with the completion of San Andreas Dam. It collects runoff from a watershed of 4.4 square miles and its current capacity is 19,000 ac-ft. The San Andreas fault passes under the eastern abutment of the dam but there was no significant damage to the dam during either the 1906 or 1989 earthquakes.

Transmission Facilities from the Pulgas Tunnel to the City

The transmission and related facilities located between the Bay Division Pipelines and the City are very extensive and are described below by system segments. It should be noted that the first Hetch Hetchy water flowed into Crystal Springs Reservoir in 1934.

Pulgas Tunnel. At Pulgas Tunnel, the water from the Bay Division Pipelines is transferred to either the Balancing Reservoir, Crystal Springs Bypass Tunnel, or Upper Crystal Springs Reservoir. The 60 mgal Crystal Springs Balancing Reservoir is used to regulate the daily cycle of flows and pressures in the system. When the supply from the Pulgas Tunnel exceeds the demand, the pumps at the Pulgas Pump Station are activated to refill the Balancing Reservoir. If the Balancing Reservoir is full, excess flows pass through the Pulgas Temple and spill into the Upper Crystal Springs Reservoir. When demand from San Francisco and the Peninsula exceeds the supply at Pulgas Tunnel, water is released from the Balancing Reservoir into the Crystal Springs Bypass Tunnel.

Crystal Springs Bypass. Other than the water diverted to Crystal Springs Reservoir, water conveyed from the Bay Division Pipelines travels by gravity through the Crystal Springs Bypass Tunnel and is routed through the Crystal Springs Pipelines No. 2 and No. 3 and the Sunset Supply Pipelines. These pipelines convey water directly to water purveyors along the Peninsula and into the City.

Crystal Springs and San Andreas Pump Stations. The Crystal Springs Pump Station and the 60-inch Crystal Springs-San Andreas Pipeline (force main) is used to transfer up to 75 mgd from Crystal Springs Reservoir to San Andreas Reservoir. Water is diverted from two outlets from the San Andreas Reservoir (No. 2 and No. 3) and is pumped to and treated at the Tracy WTP. This WTP has a capacity of 180 mgd and is used to supply upper elevation customers from Millbrae to the Sunset Reservoir in the City through the 54-inch San Andreas Pipelines No. 2 or No. 3.

Delivery to the City. In addition to the San Andreas Pipelines, water is delivered to the City via the 20-mile long Sunset Pipeline and the Crystal Springs Pipelines, and is placed in three potable water terminal storage reservoirs: Sunset, Merced Manor, and University Mound. From here, the City's distribution system delivers water directly to consumers. Demand changes from Pulgas Tunnel to the City are detected by monitoring the rate of water level changes at the above mentioned storage tanks in the City, at Pulgas Tunnel, by meters east of Pulgas Tunnel, and at the City limit.

Peninsula System Operations

The desired operation of San Andreas Reservoir is to keep the storage here as high as possible by transferring water by gravity from Pilarcitos Reservoir and by pumping water from Crystal Springs Reservoir through the Crystal Springs Pump Station and transfer pipeline. The goal at

the beginning of December is to have the combined storage for the Peninsula reservoirs at not more than 60,000 ac-ft in storage, or 20,000 ac-ft below the total storage. The goal for the storage level at the end of April is to maximize the local storage. If these goal operating levels cannot be met, then flows from the Hetch Hetchy and Alameda system will be transferred into Crystal Springs Reservoir as demand and pipeline capacity permit. However, as demands increase during the summer months, and because demands continue to increase on an annual basis, it becomes more and more difficult to make these inter-reservoir transfers.

TREATMENT FACILITIES

Since water from the local watersheds must be filtered before augmenting the Hetch Hetchy water supply, SFWD constructed and operates filtration facilities within both the Alameda system and the Peninsula system. Both facilities provide for the removal of turbidity (particulates), disinfection, and corrosion control. Disinfectant is added for microbiological control prior to filtration or added to the filtered water, to provide a residual for the distribution system. The Hetch Hetchy water is currently not filtered on a regular basis, but for disinfection and corrosion control purposes the water is treated at several points along the aqueduct. The treatment facilities for the local systems are briefly described below and their locations illustrated in Figure 2-1. Sections Five and Six of this survey provide additional information on the ability of the system to meet drinking water requirements.

Sunol Filter Plant

The Sunol WTP is a conventional WTP which sometimes is operated in a direct filtration mode. It treats local runoff which is stored in Calaveras and San Antonio Reservoirs and can treat Hetch Hetchy water at times of elevated turbidity. The Calaveras and San Antonio Pipelines are utilized to transport water from the two reservoirs to the treatment facilities. The Sunol WTP can treat up to 160 mgd. This facility disinfects with sodium hypochlorite and adjusts pH with sodium hydroxide for corrosion control.

Harry W. Tracy Filter Plant

The Tracy WTP (previously called the San Andreas Filter Plant) started operation in 1972 and was recently modified to increase its capacity from 80 mgd to 180 mgd. It was designed as a conventional plant but is operated in a direct filtration mode. The capacity expansions were only for the filtration facilities. Sodium hypochlorite and ozone are used to disinfect the water.

Sodium hydroxide is used to adjust the pH. Hydrofluosilicic acid is also added to provide fluoride in this treated water. This facility is used to supply upper elevation customers from Millbrae to the College Hill and Sunset Reservoirs in the City through the San Andreas Pipelines.

Additional Treatment Facilities

In addition to the two WTPs, there are several treatment facilities within the system. These facilities can be located in Figure 2-1. Hetch Hetchy water is first treated with lime (calcium hydroxide) at Rock River, near Oakdale in Stanislaus County. This raises the pH and adds calcium to control corrosion in the system. It is next disinfected with sodium hypochlorite at Tesla Portal. At the Alameda siphons, this treated Hetch Hetchy water is blended with water from the Sunol WTP; on average, about 85 percent is still Hetch Hetchy water as it is conveyed through the Irvington Tunnel although this percentage changes with WTP operations. The combined Hetch Hetchy and Sunol WTP water is then distributed to East and South Bay customers and to lower elevations on the Peninsula, as well as San Francisco customers (this water directly meets 25 percent of the City's demands). Hydrofluosilicic acid is added to Hetch Hetchy water along the Crystal Springs Bypass Pipeline, so all points north of the Crystal Springs Bypass receive fluoride in their water. The remaining water is conveyed from the Tracy filter plant to the upper elevations on the Peninsula and to the City distribution storage tanks. Most of the storage tanks are chlorinated again on the outlet side using chlorine or sodium hypochlorite.

In addition to the treatment facilities described above, SFWD adds copper sulfate to the four primary reservoirs, Calaveras, San Antonio, Crystal Springs, and San Andreas, to control the development of algae which clogs the filters at the filter plants. The copper sulfate is added to the reservoirs on an as needed basis usually no more than two times per year; typically once a year for each reservoir.

EMERGENCY PLANS

The SFWD currently does not have coordinated emergency response plans for natural, accidental, or vandal-caused disasters, except for those required of the Chevron pipeline owners. A seismic study was currently conducted but it does not address response procedures to seismic events. The staff contact and work with local and state agencies, as needed, when an event occurs. Watershed staff have "blue binders" available to them as emergency references, but the

watershed management have indicated that they are inadequate as an emergency response document. The SFWD maintains a 24-hour communications switchboard for both watersheds and any Millbrae emergencies. The area of the Alameda watershed within Santa Clara County has poor or non-existent radio communications for County law enforcement and emergency response personnel. The SFWD has recently identified response and notification proceedures for planned and unplanned chlorinated water discharges to waters of the State. An emergency response plan will be developed for the SFWD as a part of the current Watershed Management Plan project.

SECTION 3

ALAMEDA WATERSHED CONDITIONS

NATURAL SETTING

Although the Alameda Creek drainage basin encompasses a very large area, this WSS is focused on the lands within the southern half of the basin which directly contribute to or store the SFWD water supplies. This includes lands above the San Antonio and Calaveras Reservoirs, and lands in between the reservoir dams and the Sunol Filter Galleries within Sunol Valley. Wildlife associated with Alameda watershed is described in Section 7, Potential Contaminant Sources. Photographs of the natural setting of the Alameda watershed are provided in Appendix A.

Location

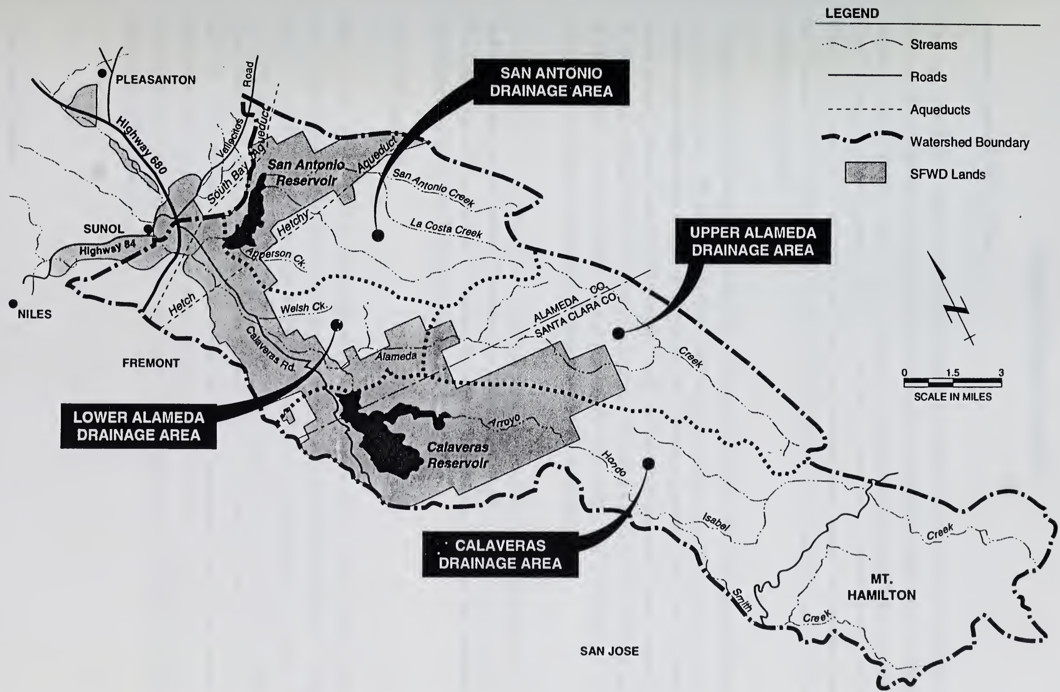
The Alameda Creek watershed lands are located in the Diablo Range portion of the Central Coast Range. The entire 633 square mile (sq. mi.) watershed extends from Mount Diablo in the north, to the Altamont Pass in the east, to Mount Hamilton in the south, and Niles Canyon to the west, as presented in Figure 3-1. The Alameda Creek watershed includes the Livermore-Amador Valley and the Sunol Valley and is within Contra Costa, Alameda, and Santa Clara counties.

Of the entire 633 sq. mi. watershed, 175 sq. mi. of land drain the southern half and include the San Antonio and Calaveras Reservoirs. This southern drainage area is the focus of this analysis. The study area is located within the USGS 7.5-minute quadrangles of Dublin, La Costa Valley, Niles, Calaveras Reservoir, Mt. Day, Mendenhall Springs, Eylar Mtn., San Jose East, Lick Observatory, and Isabel Valley. The SFWD owns approximately 63 sq. mi. within the study area. The drainage basin is described in more detail below.

The terrain varies from flat alluvial valleys of Sunol and La Costa Creek, to gently rolling hills in much of the watershed, to steep canyon walls with up to 90 percent slopes in the Arroyo Hondo and Alameda Creek gorges. Elevations vary from approximately 440 feet msl along San Antonio Reservoir to a maximum altitude of 4,372 feet msl at the peak of Mount Copernicus at the southern end of the watershed near Mt. Hamilton.

ALAMEDA CREEK WATERSHED

FIGURE 3-1



ALAMEDA WATERSHED DRAINAGE AREAS

FIGURE 3-2

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MONTGOMERY WATSON

Geologic Features of Significance

The most prominent geologic feature in the Alameda watershed is the presence of the Calaveras Fault, an active, right-lateral strike-slip fault where fault movement is dominated by horizontal motion with subordinate vertical offset. The trace of the fault is concealed through most of the Sunol Valley by stream-deposited alluvium. The fault is located along the eastern edge of the Sunol Valley entering the watershed near Sunol and traveling south parallel to Calaveras Road and Alameda Creek, across several low ridges, beneath the Calaveras Reservoir, and out of the watershed near San Jose.

In addition to the Calaveras Fault Zone, other active and potentially active faults are within and near the watershed. The principal locations that may requires special consideration are: 1) the western and southwestern margin of the watershed (Calaveras Reservoir and Lower Alameda Creek basins) which is closest to the Hayward Fault and has other Quaternary faults present; 2) the northeastern margin of the watershed (San Antonio Reservoir basin), which includes a Late Quaternary fault, and is near Holocene and historically active faults; and 3) the Arroyo de la Laguna canyon, which is immediately downslope of the Calaveras Fault.

The Sunol Valley is a gravel filled depression at the upper entrance to Niles Canyon. The undiverted waters of the Alameda Creek drainage basin flow through the entrance to this canyon. The sand and gravel deposits are so extensive that aggregate extraction operations are established by Mission Valley Rock and AMC Lonestar to mine the deposits.

Soils and Vegetation

Soils. Soils within the Alameda watershed vary from clays to sands. On the steeper upper slopes west of Calaveras Reservoir, there are large areas of San Andreas fine sandy loam. Along the lower slopes and valleys draining to the Calaveras Reservoir from the west, is a mosaic of Los Osos clay loams and Gaviota gravelly loams. Gaviota gravelly loams and the Gaviota-Los Gatos complex is dominant on the slopes and side valleys of Calaveras Creek south of the reservoir. Yolo loams have developed on the alluvial terraces immediately south of the reservoir, with Pleasanton gravelly loams and Zamora loams on some of the valley margin deposits. On the southeast side of Calaveras Creek, the only areas of Clear Lake clay and Hillgate silty clay loam on SFWD lands occur.

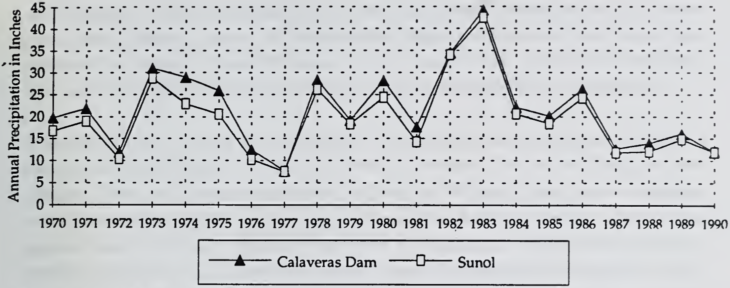
Along Arroyo Hondo, soil types south of the arroyo (the north and northeast facing slopes) are a mosaic of Los Gatos gravelly loams and Gaviota loam. The northern side of Arroyo Hondo has large areas of rock, and Gaviota loams on very steep slopes. The other major soils on the north side of Arroyo Hondo are Vallecitos rocky loams. In the vicinity of Calaveras Dam, rock land with little soil is present west and north of the dam, with Los Gatos loams and Los Osos silty clay loams on the east side of the dam and reservoir.

Near the confluence with Calaveras Creek, the slopes along Alameda Creek have areas of little or no soil, with adjacent areas of Los Gatos loams and Los Osos silty clay loams in a complex mosaic. The Los Gatos-Osos complex is common on the south side of Alameda Creek upstream of the diversion dam, with Vallecitos rocky loams prevalent along Oak Ridge. The northern side of Alameda Creek is dominated by Vallecitos rock loams along the lower slopes, punctuated by rocky outcrops. The upper slopes north of the creek have Henneke rocky loams on serpentine parent material, with rockland patches. Narrow areas of Yolo silt loams occur along stream terraces and an area of Altamont clay is adjacent to Alameda Creek at the eastern end of the SFWD lands.

Several fairly large, continuous areas of soils rated by the U.S. Soil Conservation Service as Capability Class I or II exist within the watershed. The largest area of Class I soils is in Sunol Valley, including both the Yolo and Zamora loams. Smaller and discontinuous parcels of Class I and II soils occur south of Calaveras Reservoir, east of San Antonio Reservoir, and along Alameda Creek terraces along the upper reaches.

Vegetation. The Calaveras Reservoir straddles the Calaveras fault, that separates Franciscan rocks of the Mount Hamilton Range from the Great Valley sequence of the Hayward Hills. In the vicinity of the reservoir, west facing slopes are covered with grasslands while the north- and east-facing slopes are covered with oak woodland and brush in drier locations. In the vicinity of San Antonio Reservoir, the landscape is primarily grassland with small area of brush and woodland on north-facing slopes. Riparian woodland occurs in the moister drainages especially along San Antonio Creek. Grazing is widespread in watershed grasslands.

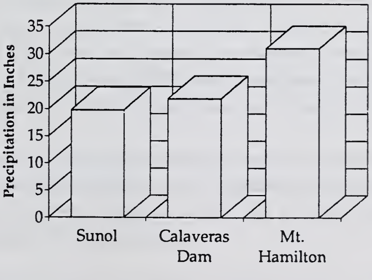
The non-native grasslands community is the dominant feature of the Alameda watershed, found on 19,170 acres of flat and gently sloping valleys. Serpentine bunchgrass is found on the northeast side of the Sunol WTP. The valley oak, California's largest broad-leafed tree is abundant around San Antonio and Calaveras Reservoirs interspersed with the grasslands. Many large specimens are also found along the top of Poverty Ridge between Calaveras Reservoir and



Source: SFWD 1993, Uribe 1994.

VARIATIONS IN TOTAL SEASONAL RAINFALL 1970 - 1990 for Sunol and Calaveras Dam

FIGURE 3-3



Source: Sunol and Calaveras Dam (SFWD 1993), Mt. Hamilton (SCVWD 1989); Uribe 1994.

MEAN ANNUAL PRECIPITATION - ALAMEDA WATERSHED

FIGURE 3-4

Arroyo Hondo. Valley oaks intergrade with scrub and chaparral communities such as northern coastal scrub, chamise chaparral, and northern mixed chaparral that occur on north-facing slopes protected from grazing. About 9,900 acres of valley oak, blue oak, and northern coastal scrub are found in the watershed. 3,140 acres of mixed evergreen/coastal live oak woodlands exist.

Sycamore alluvial woodland is a broad-leafed woodland that occurs in braided depositional channels with cobblestones and boulder substrates on 260 acres. San Antonio Creek is a prime example. Three other riparian communities are found on 340 acres in the Alameda watershed: central coast arroyo willow riparian, white alder riparian forest, and central coast live oak riparian forest. White alder riparian forest grows on the banks of rapidly flowing, perennial streams, while willow riparian occurs in moist canyons with perennial to intermittent stream flow. Coast live oak riparian forest is usually found on ephemeral stream courses. Freshwater marsh occurs on the deltaic formations created where streams and arroyos discharge to reservoirs.

Drainage Basins

The entire 633 sq. mi. Alameda Creek watershed is divided into the Livermore and Sunol drainage units, as presented in Figure 3-1. The Livermore drainage unit occupies the northern and eastern portion of the watershed. The major streams are Arroyo del Valle, Arroyo las Positas, Arroyo Mocho, and Alamo, San Ramon, and Tassajara Creeks. Arroyo del Valle and Arroyo Mocho have the largest drainage areas. These streams converge on the floor of the Livermore-Amador Valley forming Arroyo de la Laguna. Arroyo de la Laguna then picks up flows from Sinbad and Vallecitos Creeks before it joins Alameda Creek in the Sunol drainage unit in the community of Sunol (near the SFWD Sunol headquarters). The total drainage area of the Livermore unit is about 423 sq. mi., including Sinbad and Vallecitos Creeks.

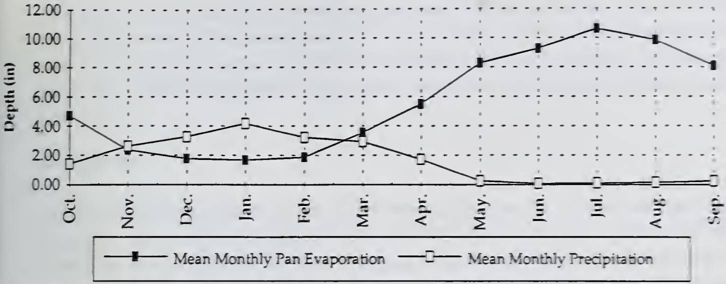
This upper drainage unit is mentioned here because the waters of Arroyo de la Laguna can be picked up at the Filter Galleries, if desired. Also, if a significant water quality problem were to occur in Arroyo de la Laguna, it appears possible that it could impact the surface or groundwaters in the vicinity of the Filter Galleries.

The 210 sq. mi. Sunol drainage unit is located in the southern half of the watershed and contains the SFWD reservoir lands. Arroyo Hondo and Calaveras Creek are the main streams in this unit and are tributary to Alameda Creek, which flows northward through Sunol Valley to Sunol where it is joined by Arroyo de la Laguna. Alameda Creek travels through Niles Canyon and out

of the study area. Other streams in this drainage unit include Smith, Isabel, Indian, Apperson, La Costa, and San Antonio Creeks.

Within the Sunol drainage unit, several drainage subareas make up the study area and are located in Figure 3-2. The Calaveras Drainage Area includes the Arroyo Hondo lands and lands adjacent to the Calaveras Reservoir, the Upper Alameda Drainage Area includes Alameda Creek lands upstream of the Alameda Diversion, and the San Antonio Drainage Area drains the entire watershed of San Antonio Reservoir. The Lower Alameda Drainage Area includes the lands downstream of the Alameda Diversion Dam and downstream of the two reservoirs, all of which drains to the Filter Galleries. Arroyo Hondo is the principal tributary to Calaveras Reservoir, capturing the runoff from nearly 60 percent of the watershed. Two of the tributaries to Arroyo Hondo, Smith and Isabel Creeks, circle Mount Hamilton, one of the highest points in the watershed. San Antonio Reservoir receives the discharges of San Antonio, Indian, La Costa, and Apperson Creeks in addition to imported water from Hetch Hetchy and emergency supplies from the SBA.

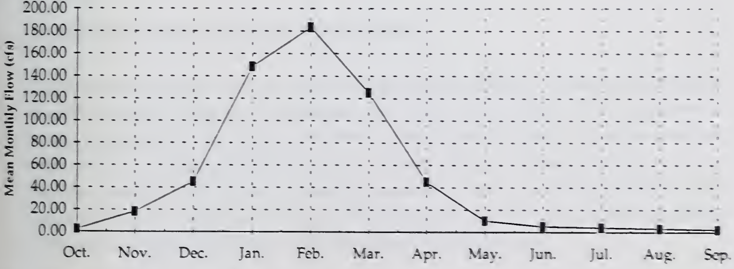
Bookman-Edmonston, Inc. has estimated the runoff contributions within the watershed utilizing available data and adjusting it to reflect local watershed conditions. The estimated runoff for the reservoirs, and estimates of flows below the San Antonio, Calaveras, and Alameda Diversion Dams are presented in Table 3-1.



Source: Pan Evaporation data are from Del Valle Reservoir (Alameda County Flood Control District, Zone 7, 1981); precipitation data are from Calaveras Dam recording station (SFWD 1993); Uribe 1994.

MEAN MONTHLY PAN EVAPORATION AND PRECIPITATION
Calaveras Reservoir Watershed (1969 - 1981)

FIGURE 3-5



Source: USGS Water Resources Data for California, 1982; Uribe 1994.

MEAN MONTHLY FLOW OF ARROYO HONDO
(1969 - 1981)

FIGURE 3-6

watershed. The evaporation data are derived from a pan evaporation gauging station at nearby Del Valle Reservoir. The seasonal distribution curve illustrates that very little precipitation is contributed during the months from May through October. The evaporation rates peak during the summer months and exceed the average annual precipitation from approximately two-thirds of the year.

Streamflows

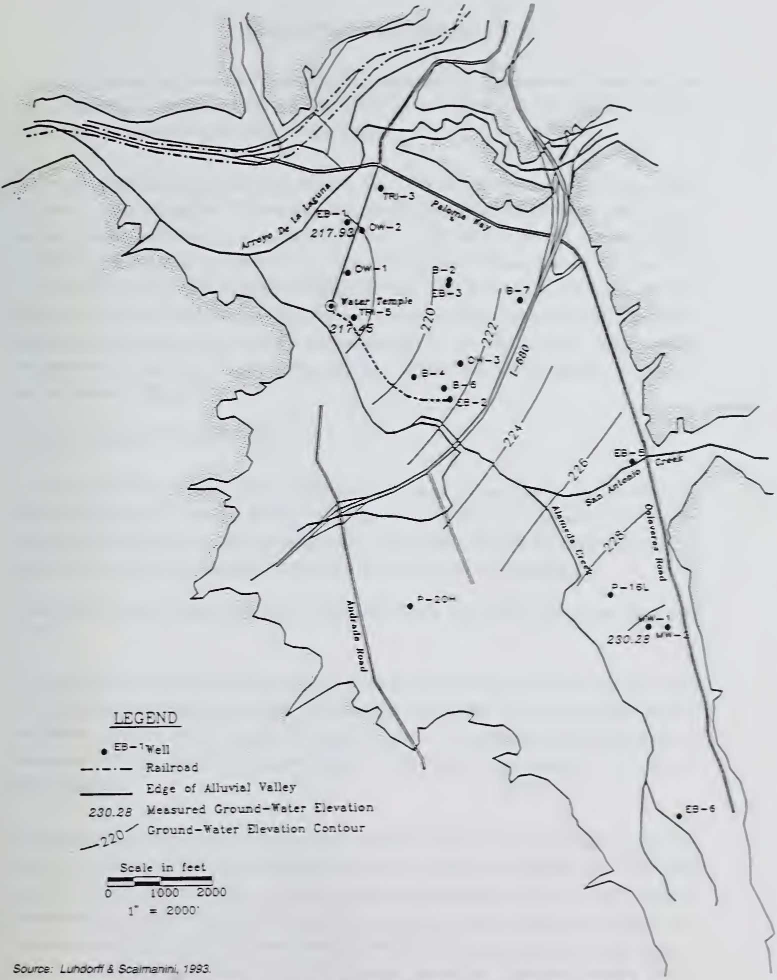
There is currently no gauging of any of the streams near the San Antonio and Calaveras reservoirs. Historically, only Arroyo Hondo had daily stream flow measurements recorded (1969-1981, and reestablished in 1994); the mean monthly flow for Arroyo Hondo is presented in Figure 3-6. The gauge was located near the Alameda and Santa Clara county line. Other creeks in the area that have stream flow records include Alameda Creek at Niles Canyon (since 1916), Arroyo Valle near Lake Del Valle (since 1963), Upper Penetencia Creek located to the southwest of the watershed (since 1961) and a new gage at the Upper Alameda Creek diversion dam (1994).

Arroyo Hondo and Alameda Creek are the only perennial streams in the San Antonio and Calaveras watersheds. Both of these streams have very little flows in the driest part of the late summer and early fall, and during dry years they may stop flowing. The remainder of the streams in the watersheds are ephemeral (intermittent) and stop flowing during the driest parts of the year.

Groundwater Under the Influence of Surface Water

As discussed in Section 2, the only significant groundwater resources within the watershed lie beneath the Sunol Valley and the Pleasanton well field. Since the Sunol Valley groundwater supply is influenced by the surface water flowing from Alameda Creek, it is subject to surface water drinking regulations which are more stringent than groundwater regulations, and is therefore included in this survey. A detailed evaluation of the groundwater conditions within Sunol Valley was conducted by Luhdorff and Scalmanini; the report was released December 1993 and is available from SFWD. A brief description is provided here.

The Sunol Valley contains two water bearing geologic units: the Livermore Gravels composed of weakly compacted and consolidated, interbedded gravel, sand, silt, and clay; and the overlying unconsolidated alluvium composed of interbedded gravel, sand, silt, and clay. Based on a small network of wells, most of which are small diameter monitoring wells, groundwater levels from a



Source: Luhdorff & Scalmanini, 1993.

GROUNDWATER ELEVATION IN THE SHALLOW ALLUVIUM

FIGURE 3-7

northerly gradient, approximately parallel to the ground surface. The location of these wells and the groundwater elevation contours are presented in Figure 3-7. The depth to shallow groundwater is typically in the range of 20 to 30 feet.

The depth of the alluvium ranges from 30 to 40 feet. It forms a highly permeable, high yielding, shallow unconfined aquifer. Permeability tests have indicated that the hydraulic transmissivity of the alluvium could be in the range of 15,000 to 45,000 gallons per day per foot (gpd/ft). However well yields are limited here by the shallow depth and thinness of the alluvium. The Livermore Gravels extend to a depth of at least 500 feet. Only a few wells have been completed into the Livermore Gravels apparently due to its weakly compacted nature and fine-grained matrix content which limits porosity and permeability, and results in low water yielding characteristics. Aquifer transmissivity was tested for one well and determined that it is very low, on the order of 3,000 gpd/ft.

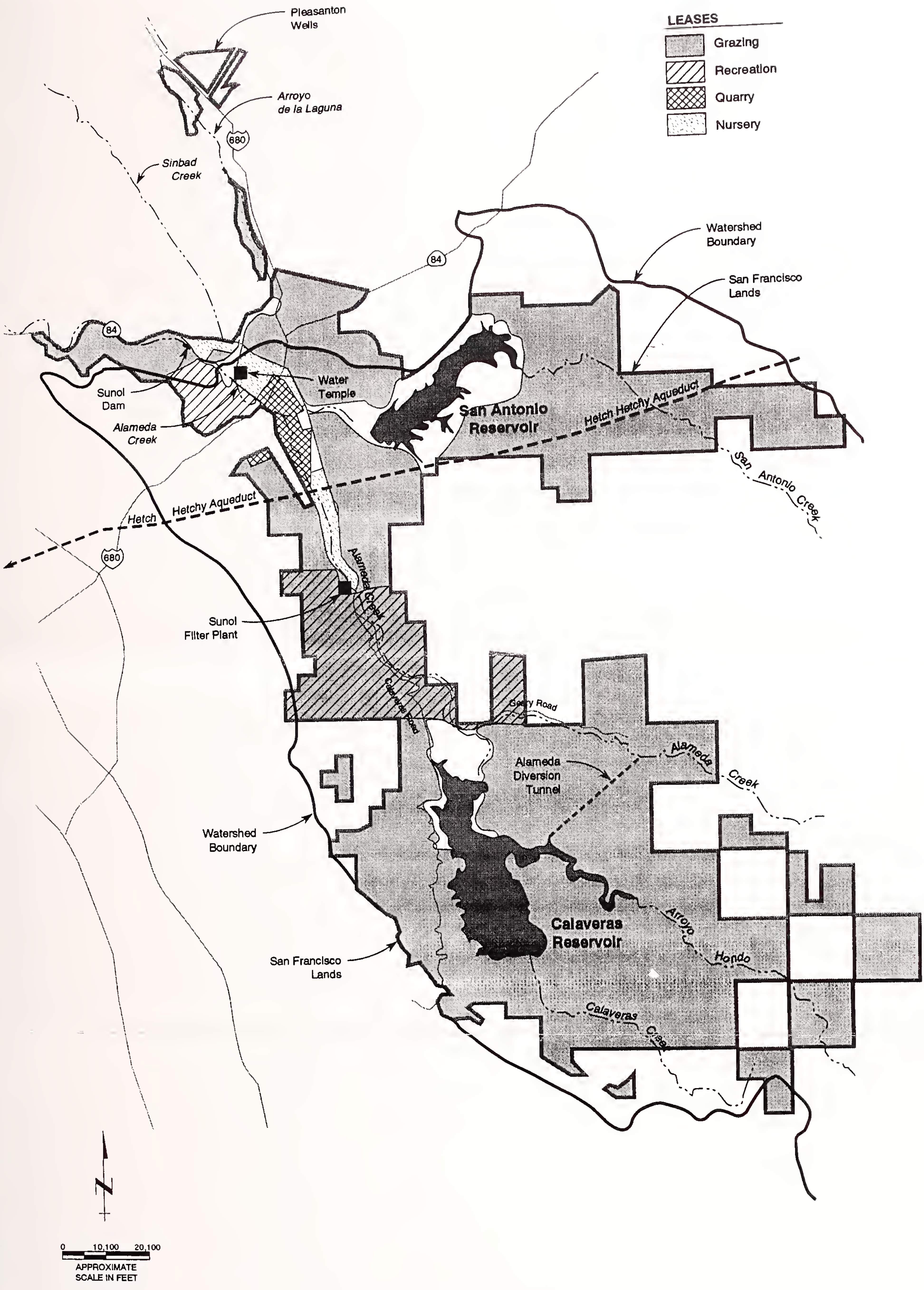
LAND USES AND OWNERSHIP

An overview of land uses within the entire Alameda Creek drainage basin (the Livermore and Sunol drainage units as defined above) is summarized here. The uses of and activities occurring on the lands within the southern drainage unit, the study area, are more thoroughly discussed in Section Seven, Potential Contaminant Sources Within the Alameda Watershed.

Overview of Land Uses in the Upper Alameda Creek Watershed (Livermore Drainage Unit)

The lands within the upper watershed are both urban and rural in nature. Five incorporated cities are completely or partially located in the watershed: Livermore, Pleasanton, Dublin, and the southeastern portions of San Ramon and Danville. Most of this urban use has occurred along the Interstate 580 and 680 corridors and consists of residential, commercial, and industrial developments.

Residential development is the primary type of urbanized land in the watershed; representing about 82 percent of the total developed urban lands. The majority of residential lands are located in the Livermore-Amador Valley. Densities average three dwelling units per acre; 97 percent is developed as low density single-family units, the remainder are medium and high densities. The remaining residential lands are concentrated in the flat land along the San Ramon Valley in Contra Costa County. Densities are slightly higher than in the Livermore-Amador Valley,



LEASED SFWD LANDS

FIGURE 3-8

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MONTGOMERY WATSON

averaging approximately five residential units per acre (ACWD, 1990). However, as the Tassajara Valley continues to develop, average densities for the San Ramon area may decrease.

Commercial uses in the upper watershed basin include the central business districts of Livermore, Pleasanton, and Dublin, Stoneridge Mall, Hacienda Business Park and Bishop Ranch office developments, and a number of neighborhood and community centers. Commercial uses represent approximately six percent of total urban developments.

Industrial development represents about 12 percent of total urban lands. The majority of industrial activity is generated from employers in Livermore at the Lawrence Livermore National Laboratory and Sandia National Laboratories. The remaining industrial lands are scattered throughout the cities. About 2,700 acres of sand and gravel quarries are located between Pleasanton and Livermore; approximately 1,500 acres are being mined or have been depleted. A hazardous waste cleanup site is located at Lawrence Livermore Laboratory, and solid waste transfer or disposal sites are located at the Altamont Hills Landfill, Vasco Road Landfill, and the Pleasanton Transfer Station. The General Electric Vallecitos Nuclear Center is located along Highway 84 adjacent to Vallecitos Creek.

Of the nonurban lands, the majority are considered cropland, rangeland, or public land and are distributed throughout the upper basin. Irrigated croplands are located in the flat valley floors of the Livermore-Amador and Sunol Valleys, while dryland farming occurs primarily in the rolling hills adjacent to these valleys. Rangeland can be found primarily north of Livermore and in the Altamont hills. Public lands include community and regional uses such as education, general government, and park and recreation sites. Regional facilities include the Alameda County Fairgrounds in Pleasanton, and the Camp Parks military reservation north of I-680.

Overview of Land Uses in Lower Alameda Creek Watershed (Sunol Drainage Unit)

The lands within the lower watershed basin are primarily rural in nature. The residential uses are very different in the lower basin; there are no cities and most people live in rural settings at very low densities. Land upstream of the reservoirs is primarily open space with some rural residential uses including low density developments in Santa Clara County at the south end of Calaveras Reservoir. Hunting cabins can be found scattered throughout the watershed. The community of Sunol has the largest concentration of urban lands within the lower watershed with a 1993 population of 517. Sunol is primarily low density residential with some commercial

lands. Other commercial lands include nurseries and miscellaneous service and retail uses along I-680 and Calaveras Road.

Two industrial facilities are located on SFWD land at the south end of Calaveras Reservoir, Quantec and Calaveras Test Site. These facilities are currently being closed down. Public lands within the watershed are primarily owned by San Francisco, East Bay Regional Park District (EBRPD), and Santa Clara County. The Lick Observatory on top of Mount Hamilton is also public land. Lands are used extensively for grazing upstream of the San Antonio and Calaveras reservoirs both within and outside of SFWD lands. These grazing lands and other lands leased from SFWD for uses such as recreation, quarries, and nurseries are presented in Figure 3-8. Specific land uses and activities within the lower basin, the study area, are discussed in detail in Section Seven.

Ownership of Watershed Lands

Lands within the 210 sq. mi. study area are owned by numerous individual entities. SFWD owns the 63 sq. mi. area identified in Figure 3-1. Oliver de Silva Co. owns land along Apperson Ridge which is targeted for future quarry operations. EBRPD owns land downstream of Calaveras Reservoir (in addition to and adjacent to that leased from SFWD, as located in Figure 3-8) . Mission Valley Rock Co. owns land in Sunol Valley adjacent to the lands that they lease from SFWD for quarry activities. There are numerous individual property owners along Welsh Creek Road and upstream of Calaveras Reservoir in Santa Clara County; some of these owners have built individual homes within the watershed.

SECTION 4

PENINSULA WATERSHED CONDITIONS

NATURAL SETTING

The SFWD owns the majority of the Peninsula watershed lands within the catchment area of the reservoirs. Within the SFWD lands, the natural drainage of Pilarcitos and San Mateo Creeks has been altered to maximize the collection and storage of waters utilizing elevation differences which minimize pumping requirements. The diversions of natural drainage courses are described in more detail within Section Two, Water Supply, Conveyance, and Treatment Systems. Wildlife associated with the Peninsula watershed are described in Section 8, Potential Contaminant Sources. Photographs of the natural setting of the watershed are provided in Appendix A.

Location

The Peninsula watershed lands are located in San Mateo County and contain the Crystal Springs, San Andreas, and Pilarcitos Reservoirs. San Andreas and Crystal Springs Reservoirs lie to the west of Interstate 280; Highway 92 travels west from I-280 across the Crystal Springs Reservoir, dividing it into the original Lower and Upper Reservoirs, and out of the watershed to the City of Half Moon Bay. Pilarcitos Reservoir is to the west of the two reservoirs. The reservoirs are located within the Montara Mountain, San Mateo, and Woodside USGS 7.5' quadrangles.

The terrain varies from the flat San Andreas Rift Zone valley south of Crystal Springs Reservoir to very steep slopes adjacent to Pilarcitos Creek downstream of the Pilarcitos Dam, and San Mateo Creek. The elevations vary from approximately 280 feet at the Crystal Springs Dam Spillway to 2,048 feet on Kings Mountain located to the southwest of Crystal Springs Reservoir.

Geologic Features of Significance

The watershed lands are geologically unique, dominated by a series of linear north-south trending ridges and faults. The major, and only active fault is the San Andreas; the three minor ones are the San Mateo, Pilarcitos, and Canada faults. The San Andreas Fault is located underneath the San Andreas and Crystal Springs Reservoirs entering the watershed from the City of San Bruno to the north, and exiting south into the City of Woodside.

Faulting is the primary factor in producing a wide range of rock formations in the watershed which in turn results in highly variable soil types and vegetation. The Franciscan assemblage is the most extensive geologic formation, located primarily east of the San Andreas Fault and containing sandstones, cherts, shales, limestones, and serpentine intrusive masses that are erratically distributed and highly deformed and sheared. The serpentine rock underlies most of the grasslands and provides habitat for many rare species. It is also a source of asbestos fibers. To the west of the fault, the quartz diorite mass of Montara Mountain in the north and the Butano sandstone formation in the south, are juxtaposed to the Franciscan complex. South of Crystal Springs Reservoir within the fault zone itself lies a mixture of Santa Clara formation and alluvium.

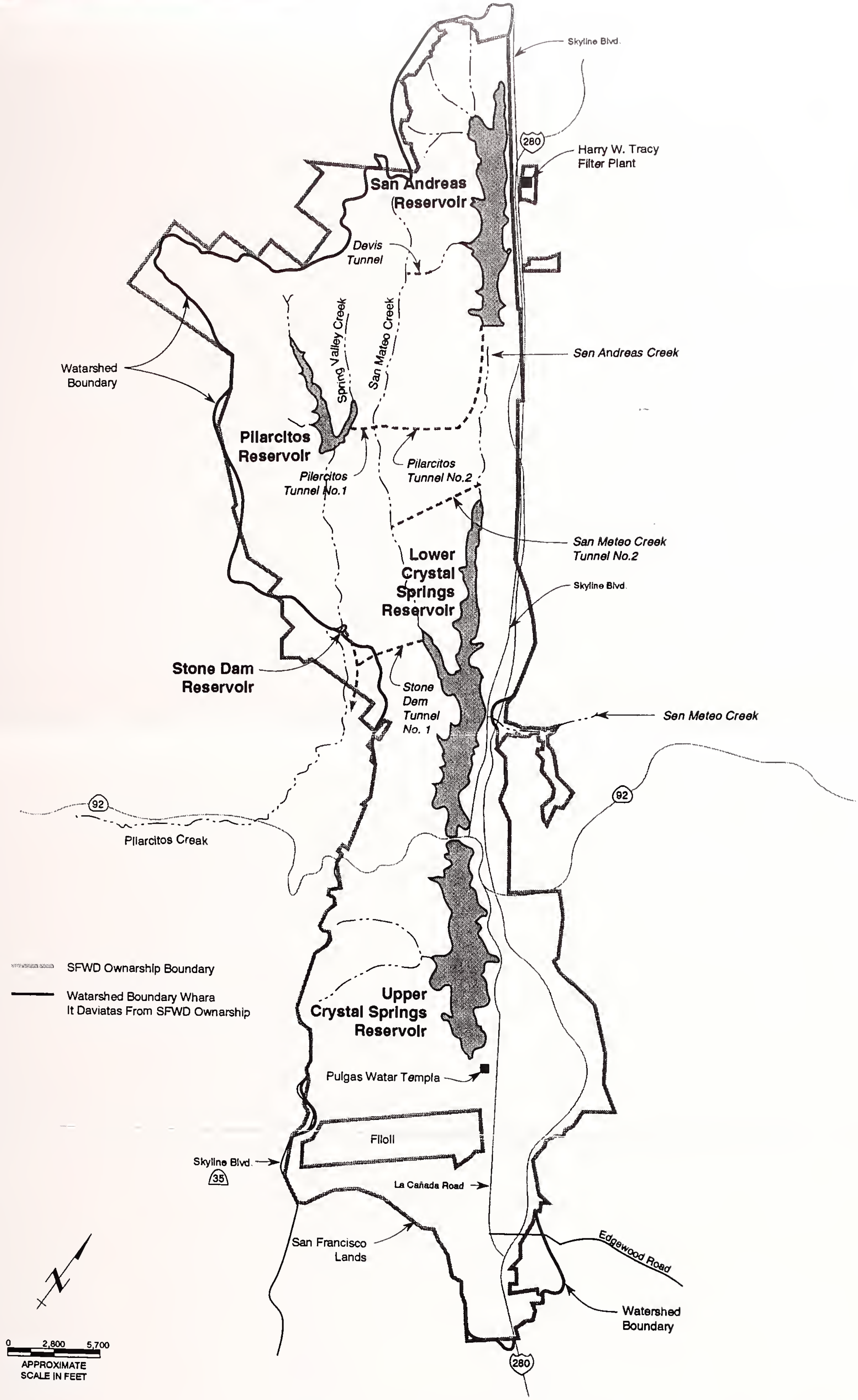
Soils and Vegetation

Soils. Soils within the Peninsula watershed vary between clays and sands. Distinct soil differences are found on either side of the San Andreas Fault which is related to parent material, local climate, and vegetation variations.

West of the Crystal Springs and San Andreas Reservoirs, the slopes are mantled with Barnabe very gravelly sandy loams and Candlestick fine sandy loams. The predominant soils developed on Butano Sandstone in the southwestern uplands are Alambique gravelly loams under mixed forest, and McGarvey loam under coastal redwood forest. Other areas on sandstone, with lower precipitation and brush/hardwood vegetation, tend to have Maymen gravelly loam soils. The east slopes of Sawyer Ridge are dominated by Zeni and Zeni Variant gravelly loams on harder bedrock, with Alambique and McGarvey soils on soft sandstone. The upper San Mateo Creek basin is dominated by Candlestick, Barnabe, and Kron soils, of varied depths based on topographic position.

Candlestick Variant loam occurs on the large alluvial deposit south of the Crystal Springs Reservoir, areas of Obispo clay soils exist to the east of Crystal Springs and San Andreas Reservoirs on serpentine rocks, Fagan and Los Gatos loams are dominant on sandstones, while a complex mix of native and altered soils is present along the eastern developed margins of the watershed.

Around Pilarcitos Reservoir, Miramar and Sheridan soils have developed on quartz diorite parent material in the northwest and west portion of the basin, with Gazos and Lobitos soils to the north. Along Spring Valley Ridge, Sweeny clay loams and stony clay loams have developed on the



PENINSULA WATERSHED BOUNDARY

FIGURE 4-1

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MONTGOMERY WATSON

Franciscan greenstone parent material. Distinct areas of the Montara stony loam are present on serpentine near the northeast end of the basin.

Vegetation. The Peninsula watershed contains a complex mosaic of numerous natural communities whose distribution is controlled by soils, sunlight, available water, and wind patterns. Several types of grassland occur: serpentine bunchgrass, needlegrass grassland, and non-native grasslands. The grassland distribution is based on soil composition and soil depth. About 3,180 acres of grassland occur within the watershed. Scrub and chaparral communities are found on drier, rockier slopes within the watershed. These 9,170 acres include northern coastal scrub, northern maritime chaparral, northern mixed chaparral, and chamise chaparral.

Forest and woodland communities are found on moister, well drained soils on about 7,400 acres within the watershed. These include mixed evergreen forest/coastal live oak woodland, Douglas fir forest/upland redwood forest, and there are over 500 acres of exotic forest including Monterey cypress, Monterey pine, and eucalyptus. Three riparian communities also exist on 680 acres within the Peninsula watershed: white alder riparian forests, central coast arroyo willow riparian forest, and coast live oak riparian forest.

Drainage Basins

The three Peninsula reservoirs are located in Figure 4-1 along with the diversion facilities discussed in Section Two of this survey. Crystal Springs Reservoir is located on the San Andreas and San Mateo Creeks. The San Mateo Creek drains Cahill and Sawyer Ridges. The older Upper Crystal Springs Dam divides the reservoir three miles from the southern end. This dam supports the roadbed for Highway 92. The dam no longer holds back water because culverts were added allowing for the two reservoir waters to flow back and forth as one water body. Crystal Springs Reservoir has a surface area of 1,492 acres and a watershed area of 24.6 sq. mi.

San Andreas Reservoir is located on the northern branch of the San Andreas Creek above Crystal Springs Reservoir. It has a surface area of 550 acres and a watershed area of 6.9 sq. mi. The reservoir receives most of its runoff from the east-facing slopes of Sweeney and Sawyer Ridges. Additional water is delivered to San Andreas Reservoir through diversion tunnels from San Mateo Creek and Pilarcitos Reservoir .

Pilarcitos Creek is on the eastern flanks of Montara Mountain west of Cahill Ridge. Runoff from the upper portions of Pilarcitos Creek are captured by Pilarcitos and Stone Dams; waters which are not picked up by Coastside County Water District (CCWD) eventually flow towards the Pacific Ocean. Pilarcitos Reservoir has a surface area of 112 acres and a watershed area of 4.3 sq. mi. Stone Dam, located two miles downstream of Pilarcitos Dam, has a watershed area of 2.1 sq. mi. This watershed is included in the Crystal Springs watershed area because the diversion tunnel allows the water to be stored in Crystal Springs Reservoir.

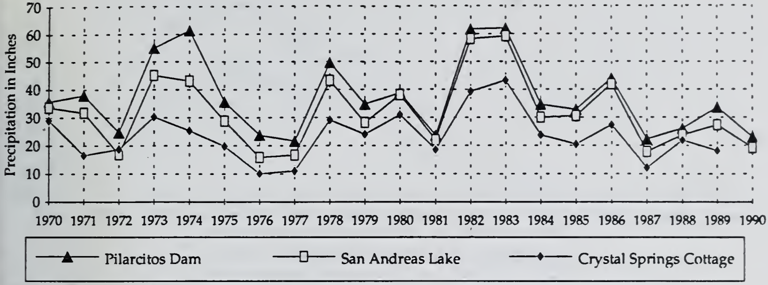
Precipitation

The SFWD collects precipitation data from several permanent stations at Crystal Springs Cottage, and at Lower Crystal Springs, Upper Crystal Springs, San Andreas and Pilarcitos Reservoirs. Precipitation in the watershed is highly seasonal. Altitude has a strong influence on the amount of precipitation. The orographic precipitation occurs as moist oceanic air currents rise over the coastal mountains and increases in volume with an increase in altitude. Approximately 90 percent of the annual precipitation occurs during the six-month period from November through April. Most of the precipitation falls during a series of regional storms that reach all parts of the Bay Area. Figure 4-2 depicts the variability of the annual precipitation between 1970 and 1990 for the reservoirs.

The average annual precipitation in the Crystal Springs and San Andreas watersheds varies between 25 to 40 inches; Pilarcitos Reservoir averages about 44 inches per year, as displayed in Figure 4-3. The highest average rainfall occurs along Sawyer Ridge to the west of San Andreas Reservoir. Some heavily wooded sections of the watershed may locally receive an additional few inches annually from fog drip. A comparison of Figure 4-4 and Figure 4-5 displays the inverse relationship between the mean monthly precipitation and the mean monthly evaporation. The evaporation data are derived from a pan evaporation gauging station in nearby Burlingame. The evaporation rate exceeds the precipitation rate throughout the summer months.

Streamflows

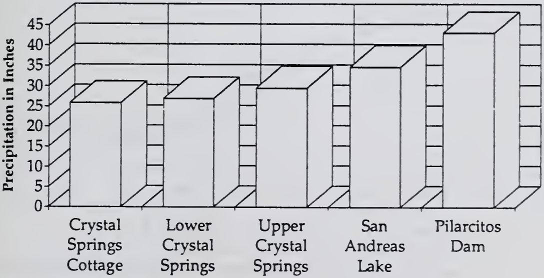
There are no stream flow records within the watershed. The only stream flow records are for Pilarcitos Creek downstream of the SFWD watershed lands, near Half Moon Bay.



Source: SFWD 1993; Uribe 1994.

VARIATIONS IN TOTAL SEASONAL RAINFALL
1979 - 1990 for Pilarcitos Dam, San Andreas Reservoir and Crystal Springs Cottage

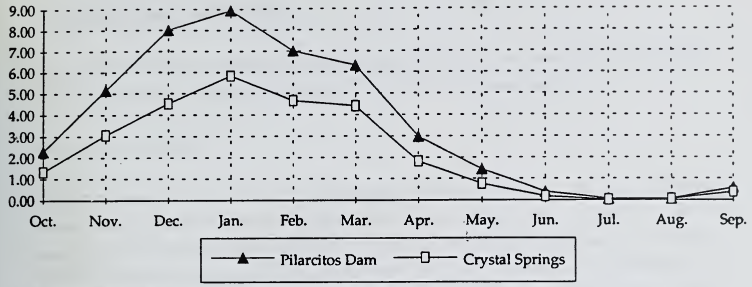
FIGURE 4-2



Source: All recording stations (SFWD 1993); Uribe 1994.

MEAN ANNUAL PRECIPITATION - PENINSULA WATERSHED

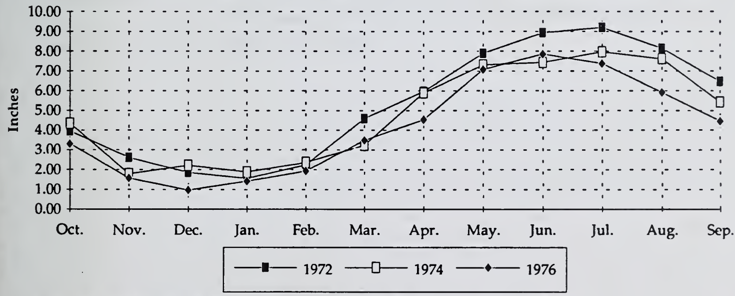
FIGURE 4-3



Source: SFWD 1993; Uribe 1994.

MEAN MONTHLY PRECIPITATION
Pilarcitos and Lower Crystal Springs Reservoirs

FIGURE 4-4



Source: National Oceanic and Atmospheric Administration, Climatological Data, 1972, 1974, 1976; Uribe 1994.

MONTHLY EVAPORATION -
BURLINGAME STATION
1972, 1974, 1976

FIGURE 4-5

LAND USES AND OWNERSHIP

An overview of land uses within the watershed is provided here, however, the uses of the lands are described in more detail in Section Eight, Potential Contaminant Sources.

Overview of Land Uses

About 99 percent of the watershed, or 23,000 acres, is owned by the City. 350 acres of privately owned lands are located along the boundary of the watershed, as shown on Figure 4-1, and 657 acres of private lands are at the Filoli Estate. Overall, the watershed is very rural in nature except for the recreational uses and the Filoli Estate which is open to the public. The watershed also contains I-280 along its length and Highway 92 across its width, straddling Crystal Springs Reservoir.

Ownership of Adjacent Lands

Adjacent to the watershed on all sides except the west, are the heavily urbanized San Mateo County cities of San Bruno, Millbrae, San Mateo, Belmont, San Carlos, and Woodside. The lands abutting SFWD lands are primarily low and medium density residential uses with individual property owners; a few of these residential parcels are actually within the drainage area of the watershed. Filoli Estate is owned by a non-profit organization which owns and maintains the buildings, gardens, and orchards.

SECTION 5

ANALYSIS OF ALAMEDA WATERSHED WATER QUALITY CONDITIONS

This section describes the quality of the surface water supplies in the Alameda Watershed, including Calaveras and San Antonio Reservoirs. Section Five begins with a review of relevant drinking water regulations which apply to SFWD's water supplies. Monitoring programs are reviewed and sources of data are listed. Existing conditions are also examined: operating criteria, intake facilities, and treatment. Given this background information, an evaluation of the water quality data is documented. Time series analyses and descriptive statistics summarize the numerous water quality parameters evaluated. As part of the evaluation, in order to highlight the high quality of SFWD's source waters, raw water qualities are compared to drinking water regulations. This evaluation technique indicates which water quality parameters require some form of treatment to achieve the current drinking water regulations. Finally, water quality recommendations can be found in Section Ten.

SUMMARY OF DRINKING WATER REGULATIONS

In the Safe Drinking Water Act of 1974 (SDWA), Congress named EPA as the regulatory authority for safeguarding our nation's drinking water. Under the provisions of the SDWA, EPA was allowed to delegate primary enforcement responsibility to states which adopted standards at least as stringent as the federal levels. In California, EPA granted primacy to the DHS. Title 22 of the California Administrative Code established DHS authority, and stipulated water quality and monitoring standards.

The SDWA specified enforceable drinking water standards which cannot be exceeded by any public water supply system. These standards may take the form of Maximum Contaminant Levels (MCLs) for specific parameters or treatment techniques. EPA also developed Maximum Contaminant Level Goals (MCLG) based solely on health effects data. MCLs are set as close as possible to the respective MCLG, depending on treatment feasibility and the reliability of laboratory methods. Both EPA and DHS have established non-enforceable, secondary standards, called Secondary Maximum Contaminant Levels (SMCL). SMCLs are used for recommending limits to protect the aesthetic quality of drinking water. Table 5-1 presents both EPA and DHS standards.

TABLE 5-1

EXISTING DRINKING WATER STANDARDS

Constituent	EPA (a) MCL	EPA (a) SMCL	California Department of Health Services (a) MCL	SMCL Recommended	SMCL Upper	SMCL Short Term
Physical Parameters						
Color (units)		15		15		
Corrosivity		non-corrosive		relatively low		
Odor (TON)		3		3		
Specific conductance (μmho/cm)				900	1,600	2,200
Total dissolved solids		500		500	1,000	1,500
Turbidity (units)	0. 5 (b)		0. 5 (b)			
pH		6.5-8.5				
Inorganics						
Antimony	0.006					
Aluminum		0.05-0.2	1			
Arsenic	0.05		0.05			
Asbestos > 10 um (MFL)	7					
Barium	2		1			
Beryllium	0.004					
Cadmium	0.005		0.010			
Chloride		250		250	500	600
Chromium	0.1		0.05			
Copper	1.3 (c)			1.0		
Cyanide	0.2					
Fluoride	4	2	1.4 - 2.4 (d)			
Iron		0.3		0.3		
Lead	0.015 (c)					
Manganese		0.05		0.05		
Mercury	0.002		0.002			
Nickel	0.1					
Nitrate (as N)	10		10			
Nitrite	1					
Total Nitrate/ Nitrite	10					
Selenium	0.05		0.01			
Silver		0.1	0.05			
Sodium		20 (e)				
Sulfate		250		250	500	600
Thallium	0.002					
Zinc		5		5		
Microorganism						
Coliform	5% (+)					
Radionuclides						
Gross alpha (pCi/L)	15		15			
Gross beta (mrem/yr)	4		50 pCi/L			
Radium-226 and -228 (pCi/L)	5		5			
Strontium-90 (pCi/L)	8		8			
Tritium (pCi/L)	20,000		20,000			
Uranium (pCi/L)			20			

TABLE 5-1 (continued)

EXISTING DRINKING WATER STANDARDS

Constituent	EPA (a)		California Department of Health Services (a)		
	MCL	SMCL	MCL	SMCL	
				Recommended	Upper
Volatile Organic Chemicals					
Benzene	0.005		0.001		
Carbon Tetrachloride	0.005		0.0005		
1,2-Dichloroethane (1,2- DCA)	0.005		0.0005		
1,1-Dichloroethylene (1,1-DCE)	0.007		0.006		
p-dichlorobenzene (p-DCB)	0.075		0.005		
1,1,1-Trichloroethane (TCA)	0.2		0.2		
Trichloroethylene (TCE)	0.005		0.005		
Vinyl chloride	0.002		0.0005		
o-dichlorobenzene	0.6				
cis-1,2-dichloroethylene	0.07				
trans-1,2-dichloroethylene	0.1				
1,2-Dichloropropane	0.005				
Ethylbenzene	0.7		0.680		
Monochlorobenzene	0.1		0.030		
Styrene	0.1				
Tetrachloroethylene	0.005		0.005		
Toluene	1				
Xylenes (total)	10		1.750		
Dichloromethane	0.005				
1,2,4-trichlorobenzene	0.07				
1,1,2-trichloroethane	0.005		0.032		
Organic Chemicals					
Alachlor (Lasso)	0.002				
Aldicarb (Temik) (f)	0.003				
Aldicarb sulfoxide	0.004				
Aldicarb sulfone	0.002				
Atrazine (Atranex, Crisazina)	0.003		0.003		
Carbofuran (Furadan 4F)	0.04				
Chlordane	0.002				
Dibromochloropropane (DBCP,Nemafume)	0.0002		0.0002		
2,4-D (Formula 40, Weedar 64)	0.07		0.1		
Endrin	0.002		0.0002		
Ethylene dibromide (EDB)	0.00005		0.00002		
Heptachlor (H-24,Heptox)	0.0004				
Heptachlor epoxide	0.0002				
Lindane	0.0002		0.004		
Methoxychlor (DMDT, Marlate)	0.04		0.1		
Polychlorinated biphenyls (PCBs, Arochlor)	0.0005				
Pentachlorophenol	0.001				
Thiobencarb			0.07	0.001	
Toxaphene	0.003		0.005		
1,1,2,2-Tetrachloroethane			0.001		
2,4,5-TP (Silvex)	0.05		0.01		
Total THMs	0.1		0.1		
Foaming Agents		0.5		0.5	

TABLE 5-1 (continued)
EXISTING DRINKING WATER STANDARDS

Constituent	EPA (a) MCL	EPA (a) SMCL	California Department of Health Services (a) MCL	SMCL Recommended	SMCL Upper
Synthetic Organic Chemicals					
Bentrazon			0.018		
Benzo(a)pyrene	0.0002				
Dalapon	0.2				
1,3-Dichloropropene			0.0005		
Di(ethylhexyl)adipate	0.4				
Di(ethylhexyl)phthalate	0.006				
Dinoseb	0.007				
Diquat	0.02				
Endothall	0.1				
Endrin	0.002				
Hexachlorobenzene	0.001				
Hexachlorocyclopentadiene	0.05				
Molinate			0.02		
Oxamyl (vydate)	0.2				
Picloram	0.5				
Simazine	0.004		0.01		
2,3,7,8-TCDD (Dioxin)	3x10-8				

January 1993

Treatnent Techniques for acrylamide and epichlorohydrin: the combination (or product) oF dose and monomer level should not exceed the following levels: acrylamide- 0.05% dosed at 1mg/L; epichlorohydrin- 0.01% dosed at 20 mg/L

(a) Concentration in milligrams per liter (mg/L) unless otherwise noted
(b) Action level based on 95% of samples
(c) Action level based on 90% of samples
(d) Applies to naturally occurring fluoride. Standards depend on temperature.
(e) Not really a secondary standard, but recommended for people on severly restricted diets
(f) On May 27, 1992, EPA suspended MCLs for aldicarb, aldicarb sulfoxide, and aldicarb sulfone. However, systems are still required to conduct monitoring for all three compounds.

In the 1986 Amendments to the SDWA, Congress issued a directive to EPA to accelerate the protection of public water supplies. Congress gave EPA three years to establish MCLs or treatment techniques for 83 water quality parameters, and required EPA to establish MCLs and MCLGs for an additional 25 parameters every three years thereafter. The Drinking Water Priority List (DWPL) identified parameters which may have adverse health effects, are known or expected to occur in public water systems, and may require regulation. Table 5-2 lists candidate parameters and indexes their status in the promulgation process. In general, EPA is continuing to finalize the Information Collection Rule, Disinfectant/Disinfection By-Product Rule - Stage I, and the Interim Enhanced Surface Water Treatment Rule. EPA has asked for various delays regarding the other five regulations summarized in Table 3.

TABLE 5-2

STATUS OF PROPOSED DRINKING WATER REGULATIONS

Anticipated Regulation	Targeted Contaminants	Status
Information Collection Rule	Microbials Physical chemical data	Proposed 3/94 Final 6/95 Begin monitor 10/95
Disinfectants/Disinfection By-Products	Disinfectants Disinfection by-products	Proposed 7/94 Final 12/96
Enhanced Surface Water Treatment Rule	*Giardia* Possibly *Cryptosporidium*	Proposed 7/94 Final 12/96
Groundwater Disinfection Rule(1)	Viruses	Proposal 8/95 Final 8/97
Arsenic(1)	Arsenic	Proposal 11/95 Final 11/97
Phase VIb Regulations(1)	VOCs, SOCs, IOCs	Proposal early 95 Final early 97
Radionuclides(1)	Uranium, Radon Radium 226 and 228 Gross beta, Gross alpha	Proposed 7/91 Final 4/95
Sulfate(2)	Sulfate	Proposed 12/94 Final 5/96

May 1995 (1) EPA seeking two-year delays in court-ordered deadlines for proposal of final versions of these regulations. (2) Sulfate regulation delayed indefinitely.

[illegible]

[illegible]

[illegible]

[illegible]

The 1986 SDWA amendments led to the Surface Water Treatment Rule (SWTR), in which EPA targeted the control of *Giardia lamblia*, viruses, heterotrophic bacteria, *Legionella,* and turbidity. DHS determined that all surface waters in California are subject to potential contamination from *Giardia lamblia* and viruses. In accordance with the SWTR, DHS requires at least 99.9 percent (3 log) reduction of *Giardia* cysts and a 99.99 percent (4 log) reduction of viruses, to be achieved through filtration and disinfection. Use of approved treatment technologies satisfies the SWTR requirements in lieu of confirmatory sampling data.

SUMMARY OF AVAILABLE WATER QUALITY DATA

Since the 1940s, the SFWD has monitored water quality in the public water supply system. SFWD tests water quality in reservoirs, along transmission pipelines, at influent points to water treatment plants, after water treatment, and throughout the distribution network. This section describes the monitoring programs and data used during the preparation of the WSS. Table 5-3 summarizes the primary SFWD monitoring efforts and Figure 5-1 shows the sampling locations.

The Water Quality Division of the SFWD was the main source of information for the Alameda Watershed. A number of long-term monitoring programs provided historical data. In 1990, the SFWD completed the first phase of a Water Quality Planning Study (WQPS). The intent of that project was to evaluate SFWD surface water supply sources for compliance with the 1986 amendments to the SDWA and updates to Title 22 of the California Administrative Code. One of the initial components of the WQPS was to compile a database on the historical water quality of raw and treated waters of the San Francisco water supply system. This database formed the original source for the analyses conducted in this chapter, updated where additional data has become available. The elements of the primary monitoring programs are summarized below.

- **Conventional Water Quality -** SFWD staff sample both Calaveras and San Antonio Reservoirs for conventional water quality parameters on an approximate weekly basis. They record in situ data (pH and temperature), and collect samples for subsequent analysis at the Millbrae laboratory (alkalinity, coliform, hardness, specific conductance, and turbidity). When compiling the WQPS database in 1990, SFWD elected to enter records for seven sampling stations over the last twenty years, 1969 to 1989. Information from both Calaveras and San Antonio Reservoirs was entered into the database to profile raw water quality in the Alameda Watershed. Discussion of this data can be found in the *Evaluation of Data* section, later in this chapter.

[illegible]

TABLE 5-3

**ALAMEDA WATERSHED
LONG-TERM MONITORING PROGRAMS (a, b)**

1940 to 1993

	Conventional WQ	Annual Monitoring	Limnology
Sample Collection	G	G	G
Frequency	W	A, SA	V
Program Term	1940-1993	1978-1993	1983-1993
Parameters			
Physical Characteristics			
Alkalinity	•	•	•
Bicarbonate		•	
Carbonate		•	
Color		•	
Conductivity	•	•	•
Hardness	•	•	•
pH	•	•	•
Temperature	•		•
Total MBAS		•	
Total Dissolved Solids (TDS)		•	
Turbidity	•	•	•
Inorganics			
Boron		•	
Chloride		•	•
Fluoride		•	
Nitrogen (Ammonia)		•	•
Nitrogen (Nitrate)		•	•
Nitrogen (Nitrite)		•	
Oxygen (Dissolved)		•	•
Phosphorus		•	•
Silica		•	
Sulfate		•	
Radionuclides			
Gross Alpha		(c)	
Gross Beta		(c)	
Strontium-90		(c)	
Tritium		(c)	

(Continued)

TABLE 5-3 (con't)

ALAMEDA WATERSHED
LONG-TERM MONITORING PROGRAMS (a, b)

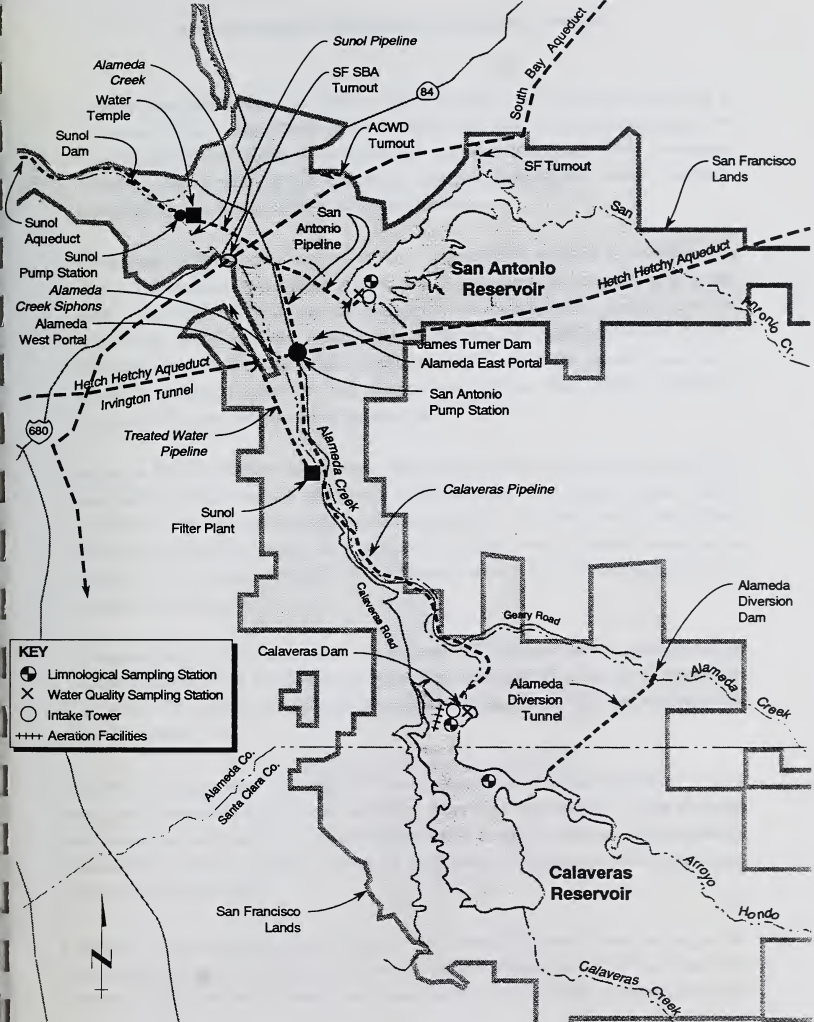
1940 to 1993

	Conventional WQ	Annual Monitoring	Limnology
Sample Collection	G	G	G
Frequency	W	A, SA	V
Program Term	1940-1993	1978-1993	1983-1993
Parameters			
Metals			
Aluminum		•	
Arsenic		•	
Barium		•	
Cadmium		•	
Calcium		•	
Chromium		•	
Copper		•	
Iron		•	
Lead		•	
Magnesium		•	
Manganese		•	
Mercury		•	
Potassium		•	
Selenium		•	
Silver		•	
Sodium		•	
Zinc		•	
Organics			
Endrin		(c)	
Lindane		(c)	
Methoxyclor		(c)	
Toxaphene		(c)	
2, 4-D		(c)	
2, 4, 5-TP Silvex		(c)	
Total Organic Carbon (TOC)			•
Microbiology			
Coliform	•		
Plankton			•
Other			
Asbestos		(c)	

(a) Source: SFWD
(b) This table does not include special studies.
(c) Supplemental component of annual monitoring program.

G: Grab
W: Weekly
A: Annual
SA: Semi-Annual
V: Varies

[illegible]



Schematic Only-Not To Scale
Source: SFWD 1993 & Systech Engineering, Inc.
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ALAMEDA WATERSHED SAMPLING STATIONS

FIGURE 5-1

MONTGOMERY WATSON

- **Annual Monitoring Reports** - SFWD conducts annual or semi-annual sampling at Calaveras and San Antonio Reservoirs and Sunol WTP. The data from this program was compiled from annual reports submitted to DHS, and span 1978 through 1992. Parameters include: general physical and mineral characteristics, inorganics, metals, asbestos, radioactivity, and a limited number of organic compounds.

- **Limnology** - SFWD profiles the vertical water quality of each reservoir as it changes with depth. The sampling team collects grab samples through the water column at up to fifteen depths. The following parameters are monitored on an on-going basis: alkalinity, chloride, conductivity, dissolved oxygen, hardness, iron, manganese, nitrate, nitrite, ammonia nitrogen, orthophosphate, pH, plankton, sulfate, temperature, TOC, and turbidity. Monthly data can be plotted to construct isopleths, or lines of equal concentration. These graphics effectively characterize the seasonal behavior of the reservoirs.

- **Algae & Copper Sulfate Application** - SFWD staff identify algal species and estimate population counts, then log this data. SFWD historical files include copper sulfate application data from two time spans--1932 through 1943, and 1966 through 1990. These documents indicate that copper sulfate was used for algae control in Alameda reservoirs as early as 1932. Application records for the Alameda reservoirs from 1966 through 1990 were compiled for this report.

- **Precipitation** - A rain gage measures precipitation at Calaveras Reservoir, and the data is made available to the Department of Water Resources (DWR) as part of a cooperative program. The monthly precipitation data included in this chapter was retrieved from the DWR database.

The SDWA Amendments of 1986 required EPA to establish drinking water standards for many unregulated parameters, and included concurrent monitoring requirements. Water suppliers could obtain waivers based on previous sampling results and/or an assessment of the system's vulnerability to specific parameters. Tables 5-4 and 5-5 list SFWD's current waivers, and those under consideration by DHS.

In addition to the on-going monitoring programs, the 1986 SDWA amendments spurred further analytical work to assess compliance with new and changing regulations. SFWD has conducted a number of special studies in recent years, investigating organics, metals, asbestos, inorganics,

TABLE 5-4

PHASE II MONITORING WAIVER INVENTORY

Parameter	Current	Grandfather (a)	Use (b)	Susceptibility (c)	Sampling Frequency
Inorganics					
Asbestos		(d)			A
Barium					A
Cadmium					A
Chromium					A
Mercury					A
Nitrate					Q
Nitrite					Q
Selenium					A
Synthetic Organic Compounds					
Alachlor	√				
Aldicarb	√				
Aldicarb Sulfone			√		
Aldicarb Sulfoxide			√		
Atrazine				(e)	
Carbofuran	√				
Chlordane	√				
DBCP				(f)	
2-4D				(g)	
EDB				(f)	
Heptachlor	√				
Heptachlor Epoxide	√				
Lindane				(h)	
Methoychlor				(h)	
PCBs			√		
Pentachloralphenol			√		
Toxaphene				(h)	
2, 4, 5-TP (Silvex)				(i)	
Volatile Organic Compounds					
cis-1, 2-Dichloroethylene		(j)			A
1, 2-Dichloropropane		(j)			A
Ethylbenzene		(j)			A
Monochloralbenzene		(j)			A
o-Dichlorobenzene		(j)			A
Styrene		(j)			A
Tetrachloralethylene		(j)			A
Toluene		(j)			A
trans-1, 2-Dichloroethylene		(j)			A
Xylenes (total)		(j)			A
Treatment Chemicals					
Acrylamide			√		
Epichlorohydrin			√		

(a) Grandfathered Data--States may allow data collected between 1/1/88 and 12/31/92 to satisfy initial base sampling requirements, if consistent with #141.24(h).
(b) Use Waiver--If a contaminant has not been used, manufactured, and/or stored within a certain area of the water source, the system may be eligible for a waiver.
(c) Susceptiblility Waiver--If adequate protection provided for source and wellhead, program reports, previous sample results, environmental transport and fate of the contaminant, systems may be eligible for a waiver.
(d) Previous sampling date: 12/90.
(e) Previous sampling dates: 6/89, 10/89, 12/89, 10/92.
(f) Previous sampling dates: 12/88, 3/89, 10/89, 12/89, 7/90, 10/90, 10/92.
(g) Previous sample dates: 10/89, 12/89, 10/92.
(h) Previous sample dates: 2/91, 10/92.
(i) Previous sample dates: 10/89, 12/89, 2/91, 10/92.
(j) Previous sample dates: 12/88, 3/89, 6/89, 10/89, 12/89, 2/90, 7/90, 10/90, 10/92.
A: Annual sampling.
Q: Quarterly sampling.

Source: SFWD, 1994

TABLE 5-5

PHASE V MONITORING WAIVER INVENTORY

Parameter	Current	Grandfather (a)	Use (b)	Susceptibility (c)	Sampling Frequency
Inorganics					
Antimony					A
Beryllium					A
Cyanide			√		
Nickel					A
Sulfate					A
Thallium					A
Synthetic Organic Compounds					
Dalapon			√		
Di(ethylhexyl)adipate			√		
Di(ethylhexyl)phthalate	√				
Dinoseb			√		
Diquat			√		
Endothal			√		
Endrin			√		
Glyphosate	√				
Hexachlorobenzene			√		
Hexachlorocyclopentadiene			√		
Oxamyl (Vydate)			√		
Benzo(a)pyrene			√		
Picloram			√		
Simazine				(d)	
2, 3, 7, 8-TCDD (Dioxin)			√		
Volatile Organic Compounds					
Dichloromethane		(e)			A
1, 2, 4-Trichlorobenzene		(e)			A
1, 1, 2-Trichloroethane		(e)			A
Unregulated Synthetic Organic Compounds					
Aldrin			√		
Butachlor			√		
Carbaryl			√		
Dicamba			√		
Dieldrin			√		
3-Hydroxycarbofuran			√		
Methomyl			√		
Metalchlor			√		
Metribuzin			√		
Propachlor			√		

(a) Grandfathered Data--States may allow data collected between 1/1/88 and 12/31/92 to satisfy initial base sampling requirements, if consistent with #141.24(h).
(b) Use Waiver--If a contaminant has not been used, manufactured, and/or stored within a certain area of the water source, the system may be eligible for a waiver.
(c) Susceptiblility Waiver--If adequate protection is provided for source and wellhead, program reports, previous sample results, environmental transport and fate of the contaminant, systems may be eligible for a waiver.
(d) Previous sample dates: 6/89, 10/89, 12/89, 10/92.
(e) Previous sampling dates: 12/88, 3/89, 6/89, 10/89, 12/89, 2/90, 7/90, 10/90, 10/92.
A: Annual sampling. Source: SFWD, 1994

pathogens, radionuclides, THMs, and D/DBPs throughout the water supply system. Special sampling of water and sediment was also conducted in February 1995 for Calaveras Reservoir as part of the on-going Alameda Creek fish studies. These special studies supplement the on-going monitoring programs listed in Table 5-3.

PHYSICAL CONTROL FACILITIES

Section Two of this report supplies a broad overview and specific details on the water system infrastructure. This following section provides further background information. Understanding the infrastructure, both water sources and transfer capabilities, provides the basis for assessing the concomitant impacts on water quality. A list of the criteria guiding reservoir operation is included here along with a description of the intake facilities and water treatment practices.

Reservoir Operating Criteria

The Raker Act, described previously in Section Two, allows for the use of the imported Hetch Hetchy supply and requires maximum use of local resources--Alameda and Peninsula watersheds. General principles guiding water management and operations in the Alameda watershed system developed by SFWD reflect this stipulation.

- By December 1st, the water level in the reservoirs is lowered by the anticipated amount of runoff in the catchment area for an average annual year.

- By April 1st, maximize the volume in storage.

To follow these principles, in late autumn the SFWD draws down Calaveras Reservoir by 12,000 mgal. They accomplish this by delivering the water to consumers or transferring it to San Antonio Reservoir or the Peninsula. Likewise, the SFWD reduces San Antonio's storage by 1,900 mgal, by using the water, conveying it to the Peninsula system, or reducing transfers from Hetch Hetchy, Calaveras Reservoir, and/or the State Water Project. Table 5-6 displays storage objectives in a tabular format. Reservoirs are kept at or below intermediate goal levels from December to April to avoid spilling winter runoff.

TABLE 5-6

ALAMEDA WATERSHED RESERVOIR OPERATION

Reservoir	Average Annual Watershed Production (mgal)	April Storage Target (mgal)	December Storage Target (mgal)
Calaveras	12,000	31,500	19,500
San Antonio	1,900	16,500	14,600
Total	**13,900**	**48,000**	**34,100**

Source: SFWD, 1994

Table 5-7 summarizes production of the Alameda reservoirs between 1990 and 1994. These estimates are based on changes in reservoir storage levels, calculated on a monthly basis. This table uses the SFWD fiscal year, from July 1 through June 30.

In 1990 and 1991, water levels in Calaveras Reservoir were drawn down to allow construction activities, and withdrawals exceeded runoff. During 1992, all inflow was stored in the reservoir; no water was released to Sunol WTP. The hydraulic residence time of the stored water can exceed one year.

In both 1991 and 1992, more water was taken from San Antonio Reservoir than the drainage area contributed. During both of these years, it is important to note that the State Water Project supplied roughly one to two thirds of the input to San Antonio Reservoir. Changes in some water quality characteristics reflect these transfers. The stored water generally has a hydraulic residence time of less than one year.

Intake Protection Features

A wet intake tower (also called a reservoir outflow structure) typically has a number of intake structures or ports at various depths as shown in Figure 5-2. Calaveras Reservoir has three intake ports, each equipped with debris and fish screens, while San Antonio Reservoir has five. This allows operational flexibility so that the highest quality water can be withdrawn from the reservoir, given a range of water levels and limnological scenarios. When the reservoirs are

TABLE 5-7

ALAMEDA WATERSHED PRODUCTION(a)

Year(b)	Calaveras Reservoir		San Antonio Reservoir		Alameda Watershed Total(c)	
	mgal	ac-ft	mgal	ac-ft	mgal	ac-ft
1994	4,420	1,440	-457	-149	4,223	1,376
1993	21,225	6,914	10,979	3,576	32,463	10,574
1992	9,308	3,032	9,392	3,059	18,903	6,157
1991	4,189	1,364	12,531	4,082	16,693	5,437
1990	539	176	119	39	957	312

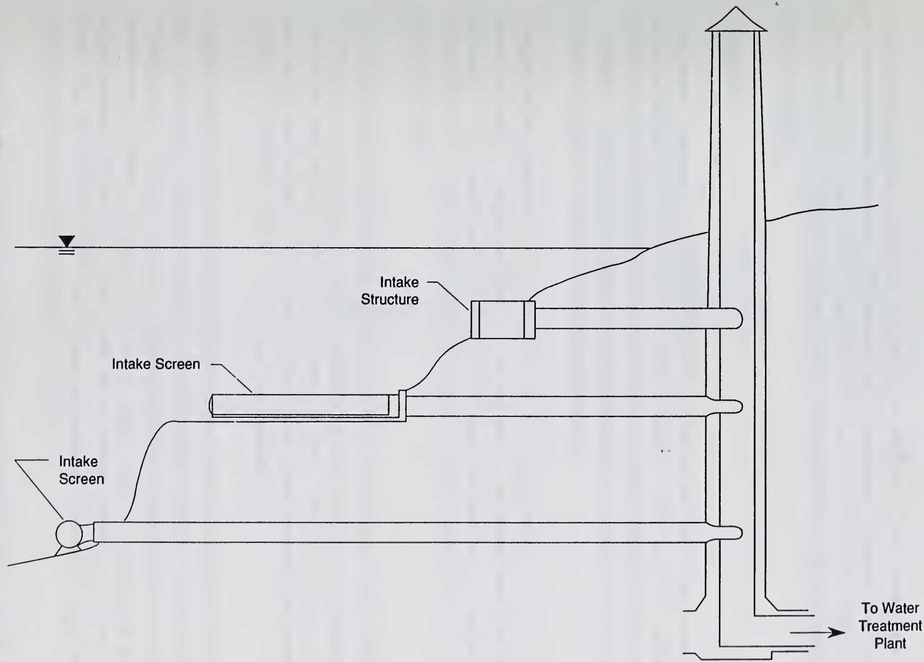
Source: SFWD, 1994

Notes:

(a) Production indicates change in storage on a monthly basis, summed over fiscal year.

(b) Based on SFWD fiscal year, July 1 through June 30.

(c) Alameda Watershed subtotal includes other sources: Pleasanton Wells and Alameda Creek.



Source: SFWD, 1994.

INTAKE TOWER STRUCTURE

FIGURE 5-2

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MONTGOMERY WATSON

stratified, phytoplankton populations are generally more numerous in the uppermost twenty feet of the water column, diminishing with depth as the light attenuates. By drawing water from the port closest to the twenty to forty foot depth, the water is low enough in phytoplankton concentrations to avoid filtration problems, yet high enough in dissolved oxygen to minimize the metals in solution.

Treatment

Two forms of treatment are performed by SFWD within the reservoirs - algal control using copper sulfate and hypolimnetic aeration in Calaveras Reservoir to alleviate anoxic conditions in the lower water depths during summer and fall. Alum is not applied to reservoirs or tributaries as a coagulant. Taste and odor problems are addressed downstream at the Sunol WTP, through aeration, chlorination, or addition of potassium permanganate.

Copper Sulfate Application. The Sunol WTP experiences algal problems from time to time, which can result in clogging of filters, or taste and odor in the treated water delivered to consumers. This is caused mostly by the growth of algae in the reservoirs. According to the WQPS, there are no records of filter-clogging algae at San Antonio, although there have been taste and odor algae.

When SFWD staff encounter an algae bloom in the reservoir, they sample vertically through the water column, and identify the algal species, population densities, and depth. (Problem algae are listed in the microbiology sections of the *Evaluation of Data*.) From this information, SFWD staff can optimize the copper sulfate dosage. The algicide is then broadcast to the reservoir in quadrants. Landmarks on shore aid in achieving a consistent application.

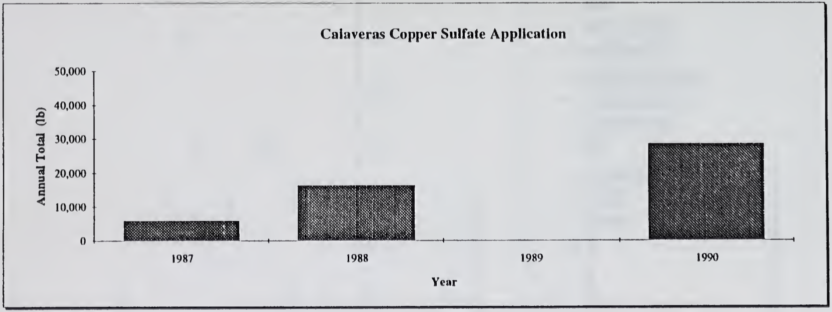
Copper sulfate applications in Calaveras and San Antonio Reservoirs are shown in Figures 5-3 and 5-4, respectively. Between 1932 and 1942 SFWD applied an average of 35,700 lb of copper sulfate per year to Calaveras Reservoir. Calaveras Reservoir has only four years of recent data, yet the average amount of copper sulfate used is roughly one third of the average amounts applied between 1932 and 1943. There is data on San Antonio Reservoir from 1966 through 1990. Since the mid-1970s, SFWD has reduced the amount of copper sulfate applied to San Antonio Reservoir by an order of magnitude. See Figure 5-4.

Concentrations of copper in the raw water are well below the treated water or drinking water MCL of 1.3 mg/L, established to protect human health. However, aquatic organisms have

FIGURE 5-3

CALAVERAS RESERVOIR
COPPER SULFATE APPLICATION

1987-1990



Monthly Copper Sulfate Application

(lb)

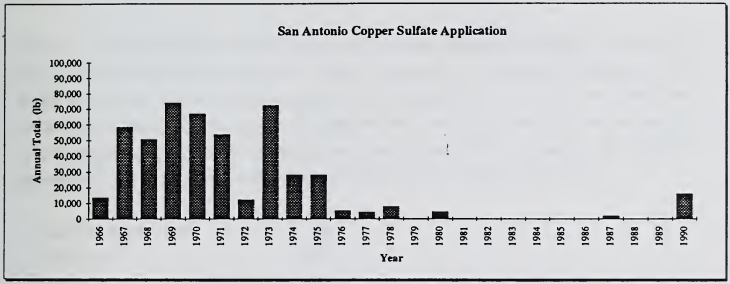
Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Total
1987							6,000						6,000
1988										16,350			16,350
1989													0
1990		12,650			10,935						4,950		28,535

Source: SFWD, 1994

FIGURE 5-4

SAN ANTONIO RESERVOIR
COPPER SULFATE APPLICATION

1966-1990

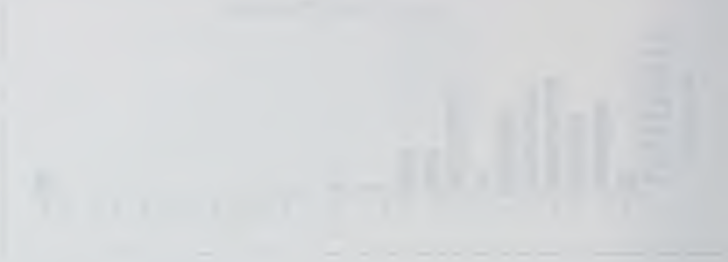


Monthly Copper Sulfate Application

(lb)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Total
1966											13,700		13,700
1967							22,720		18,160			17,680	58,560
1968					28,000			22,720					50,720
1969					20,240		28,300		25,700				74,240
1970				19,200			16,720		16,240		15,040		67,200
1971				18,960		19,360					15,520		53,840
1972									12,400				12,400
1973					21,200			25.700		25,700			72,600
1974						28,400							28,400
1975				28,400									28,400
1976		2,000						3,435					5,435
1977					4,350								4,350
1978										8,000			8,000
1979													0
1980							4,700						4,700
1981													0
1982													0
1983													0
1984													0
1985													0
1986													0
1987							2,000						2,000
1988													0
1989													0
1990							6,100				9,950		16,050

Source: SFWD, 1994



demonstrated a higher sensitivity to copper, and consequently regulatory and public agencies have focused their efforts on reducing sources of copper influent to wastewater treatment plants. Within this context, the use of copper sulfate as an algicide has come under review in the San Francisco Bay area.

In 1994, SFWD participated on the Copper and Selenium Steering Committee, a cooperative effort of South San Francisco Bay water retailers, suppliers, and municipal dischargers. This group investigated the amount of copper in the background water supply, and specifically assessed the contribution from the use of copper sulfate as an algicide and also from corrosion of copper plumbing. The report estimated that water from SFWD comprised the following percentages of local purveyors within the wastewater treatment plant service areas:

- San Jose/Santa Clara 9%
- Sunnyvale 45%
- Palo Alto 75%

SFWD copper sulfate practices were estimated to comprise the following percentages of the total annual influent copper load at each respective wastewater treatment plant:

- San Jose/Santa Clara 0.1%
- Sunnyvale 0.6%
- Palo Alto 1%

The report concluded the following:

"...The background water supply represents a relatively small percentage of the total copper load to the [wastewater treatment plants.] Much of the water from surface water supplies is removed at the water treatment plants. Actions that should obtain any further removals from the background water supply would either affect the ability of the water suppliers to meet drinking water standards, or they would be cost prohibitive. Therefore, no further actions are recommended to reduce this source..."

"...Copper sulfate is added to the water supply as an algicide. This report shows that the quantity of this copper reaching [wastewater treatment plants] is minimal. No effective alternative to copper sulfate has been found; however, both DWR and SFWD have significantly reduced the

dosage of copper sulfate when they need to treat the water. Both agencies commit to continue this reduced dosage in all copper sulfate applications..."

Water from the Alameda watershed constitutes approximately eleven percent of the SFWD water transferred to the South Bay. Alameda comprises a similar proportion of the total SFWD system production, approximately ten percent. Any copper sulfate applied to the Alameda reservoirs is greatly diluted by Hetch Hetchy water.

SFWD provides drinking water while protecting public health. Staff have tried to minimize the use of copper sulfate, while maintaining high standards and safeguarding public health. The reductions shown in Figure 5-4 demonstrate the results of SFWD's efforts.

Hypolimnetic Aeration. Hypolimnetic aeration within Calaveras Reservoir has replaced the spray aeration basins which were located upstream of the Calaveras Pipeline (transmission pipeline). The new aeration facilities were constructed as part of the Sunol WTP modifications in 1992. The purpose of the hypolimnetic aeration is to lower the concentrations of dissolved iron, manganese, and hydrogen sulfide occurring in the raw water.

Sunol Filter Plant. The Sunol WTP is a conventional WTP which sometimes is operated in a direct filtration mode. Sunol WTP provides treatment of local runoff which is stored in Calaveras and San Antonio Reservoirs. As discussed previously, the Calaveras Pipeline and San Antonio Pipeline transport water from the two reservoirs to the treatment facilities. Hetch Hetchy water can also be diverted to the plant for treatment, if necessary. Hetch Hetchy water needs filtration only during episodes of elevated turbidity (cloudiness due to fine suspended sediment), usually in winter months. This facility disinfects with sodium hypochlorite and adjusts pH with sodium hydroxide for corrosion control. The Sunol WTP can treat up to 160 mgd.

EVALUATION OF DATA

This section includes a review of existing water quality data provided by the SFWD for the WSS. Limnological profiles show the seasonal behavior of each reservoir. In the raw water, few parameters exceed the drinking water standards. For these parameters, time series graphs which display historical concentrations and statistical summaries are used to describe occurrence and concentrations. Treated water quality data indicate that treatment is effective at lowering concentrations of currently regulated parameters.

Description of Existing Water Quality

Historical water quality data collected as part of SFWD monitoring efforts is summarized in Tables 5-8, 5-9, 5-10, and 5-11. There is a discussion of water quality in the reservoirs and parameters of concern are identified. The limnological profiles depicted in Figures 5-5 and 5-6 were compiled from data collected from 1988 through 1990, years during which California experienced drought conditions. Evidence of seasonal behavior can be clearly seen in these graphs. In general, the water quality fluctuates more widely in San Antonio, reflecting the impact of water transfers into the reservoir. Water quality characteristics in Calaveras remain more consistent.

Physical Characteristics. Monthly turbidity data span from 1969 to 1989, and strong seasonal trends are evident in the raw waters of Calaveras Reservoir. Between February and April, average monthly turbidity levels range between 14 and 19 NTU. Between July and November, the average value is between 2 and 3 NTU. After periods of heavy rainfall, Sunol WTP operators have measured raw water turbidity levels exceeding 100 NTU.

San Antonio Reservoir also exhibits seasonal behavior, although not as distinctly defined as Calaveras. From February to May average monthly turbidities range between 6 and 11 NTU. September through December monthly turbidities average less than 3.5 NTU. Temperature varies on a seasonal basis in both reservoirs, and drives the extent and degree of thermal stratification. This parameter is discussed in more detail in the *Limnology* section to follow.

Mineral Quality. The weekly reservoir monitoring program formed the basis for these summaries of mineral water quality as shown in Table 5-8. This monitoring program has over twenty years of records entered in database format, with 400 to 1,000 data points per parameter. In general, the wider ranges of parameters (and higher standard deviations) in San Antonio Reservoir reflect the impacts of water transfers.

The pH in Calaveras Reservoir averages 7.88, and is relatively consistent with a standard deviation of 0.29. The levels range from a maximum of 9.3 to a low of 7.1. pH varies seasonally, and is correlated with algal growth and temperature stratification. (Please see *Limnology* for further detail.) The pH of San Antonio Reservoir averages 8.14, and fluctuates more widely with a standard deviation of 0.51.

TABLE 5-8

ALAMEDA WATERSHED
CONVENTIONAL WATER QUALITY

1969 to 1989

Calaveras Reservoir		San Antonio Reservoir	
Alkalinity	mg/L	**Alkalinity**	mg/L
Number of Samples	876	Number of Samples	982
Mean	99.61	Mean	95.13
Median	98	Median	106
Standard Deviation	13.9	Standard Deviation	40.55
Standard Error	0.47	Standard Error	1.29
Minimum	14	Minimum	12
Maximum	170	Maximum	274
Lower Quartile	92	Lower Quartile	68
Upper Quartile	106	Upper Quartile	126
Coliform	% positive	**Coliform**	% positive
Number of Samples	891	Number of Samples	994
Mean	38.96	Mean	38.57
Median	35	Median	30
Standard Deviation	32.17	Standard Deviation	30.66
Standard Error	1.08	Standard Error	0.97
Minimum	0.00	Minimum	0.00
Maximum	100	Maximum	100
Lower Quartile	10	Lower Quartile	13
Upper Quartile	65	Upper Quartile	64
Hardness	mg/L	**Hardness**	mg/L
Number of Samples	876	Number of Samples	982
Mean	110.43	Mean	109.8
Median	108	Median	120
Standard Deviation	18.51	Standard Deviation	47.46
Standard Error	0.63	Standard Error	1.51
Minimum	12	Minimum	12
Maximum	408	Maximum	352
Lower Quartile	100	Lower Quartile	84
Upper Quartile	118	Upper Quartile	142
pH	pH units	**pH**	pH units
Number of Samples	876	Number of Samples	980
Mean	7.88	Mean	8.14
Median	7.9	Median	8
Standard Deviation	0.29	Standard Deviation	0.51
Standard Error	0.01	Standard Error	0.02
Minimum	7.1	Minimum	7.2
Maximum	9.3	Maximum	10
Lower Quartile	7.7	Lower Quartile	7.8
Upper Quartile	8	Upper Quartile	8.3

(Continued)

TABLE 5-8 (con't)

ALAMEDA WATERSHED
CONVENTIONAL WATER QUALITY

1969 to 1989

Calaveras Reservoir		San Antonio Reservoir	
Specific Conductance	µmho/cm	**Specific Conductance**	µmho/cm
Number of Samples	876	Number of Samples	982
Mean	247.12	Mean	270.88
Median	248.5	Median	297
Standard Deviation	37.55	Standard Deviation	109.35
Standard Error	1.27	Standard Error	3.49
Minimum	34	Minimum	34
Maximum	564	Maximum	764
Lower Quartile	224	Lower Quartile	230
Upper Quartile	265	Upper Quartile	336
Temperature	°F	**Temperature**	°F
Number of Samples	392	Number of Samples	506
Mean	52.68	Mean	54.81
Median	52	Median	54
Standard Deviation	6.85	Standard Deviation	6.34
Standard Error	0.35	Standard Error	0.28
Minimum	36	Minimum	41
Maximum	72	Maximum	76
Lower Quartile	48	Lower Quartile	50
Upper Quartile	58	Upper Quartile	59

Source: WQPS (SFWD, 1990)

TABLE 5-9

CALAVERAS RESERVOIR
ANNUAL MONITORING REPORTS (a)

1978 to 1992

Parameters	units	Drinking Water Standards limit	type	Regulatory Authority	4/21/78	6/21/79	10/10/80	4/10/81	10/20/82	7/26/83	1/31/84	9/18/84	10/23/85	11/14/86	9/21/87	9/6/88	8/29/89	9/12/90	9/16/92
Physical Characteristics																			
Alkalinity	mg/L				87.3	110	96	84	104	100	89.0	102	116	99.3	97.9	112.4	117	128	112
Bicarbonate	mg/L				106.5	132.6	117.1	102	59	110	92	114.9	137	120	115.8	109.8	135	NS	NS
Carbonate	mg/L				0.0	0	0.0	1.2	1.6	2.6	0	4.5	2.2	0.5	1.8	2.5	4.0	NS	NS
Color	units	15.	SMCL	EPA, DHS	20	0	0	5	0	5	0	0	0	25	5	5	0	10	NS
Conductivity	µmho/cm				252	255	204	215	233	255	227	261	284	247	245	292	288	311	287
Hardness	mg/L				99	120.2	104	96.	112	104	96.0	110	120	103	99.7	116.2	122	132	123
pH	units	6.5-8.5	SMCL	EPA	7.9	8.1	7.9	8.8	8.4	8.6	8.1	8.9	8.5	8.0	8.6	8.4	8.8	8.6	8.3
Total ABS					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	NS	NS	NS	NS
Total Dissolved Solids (TDS)	mg/L	500.	SMCL	EPA, DHS	155	164	146	146	126	150	141	148	167	143	144	160	173	187	172
Turbidity	NTU	0.5 (b)	MCL	EPA, DHS	6.4	0.35	0.75	0.25	0.5	0.9	5.5	0.4	0.8	1.8	0.9	1.1	0.9	3.2	0.8
Inorganics																			
Boron	mg/L				0.13	0.1	0.10	0.26	0.18	0.15	0.05	0.21	0.16	0.4	0.3	0.5	0.2	0.3	NS
Chloride	mg/L	250.	SMCL	EPA, DHS	10.5	8.4	10	10	14	7.0	7.0	7	10	6.3	7.3	7.2	7.3	10	8
Dissolved Oxygen	mg/L				10.1	8.2	8.8	11.0	8.8	8.5	10.3	7.9	8.7	8.4	8.5	8.2	9.0	NS	10.0
Fluoride	mg/L	1.4-2.4(c)	MCL	DHS	0.15	0.10	0.09	0.10	0.10	0.03	0.12	0.09	0.15	0.1	0.12	0.13	0.14	0.2	0.1
Hydroxide	mg/L				0.0	0	0.0	0	0	0	0	0	0	<0.2	0.0	NS	NS	NS	NS
Nitrate	mg/L	10.	MCL	EPA, DHS	2.4		0.65	2.8	0.31	1.6	1.8	1.7	1.8	1.6	0.7	0.0 (d)	0.3	<0.1	<0.4
Nitrite	mg/L	1.	MCL	EPA	0.003	<0.003	<0.001	0.001	0.001	<0.002	0.004	0.002	<0.001	0.002	<0.003	0.01	0.003	0.01	<0.3
Phosphate	mg/L				0.08	<0.01	0.03	0.05	0.05	<0.05	0.11	<0.05	0.05	<0.01	<0.001	0.048	0.013	<0.01	NS
Silica	mg/L				10.5	2.5	3.8	7.7	5.8	9.7	11.7	6.2	6.8	4.2	5.5	NS	2.1	0.5	NS
Sulfate	mg/L	250.	SMCL	EPA, DHS	18	21.4	14.0	22.3	14	14.0	15.6	16.4	4.1	12.3	20.5	20.1	23.8	26	31
Metals																			
Aluminum	mg/L	1. (e)	MCL	DHS	0.07	<0.02	0.03	<0.10	<0.10	0.06	0.02	0.01	0.02	0.02	0.13	0.07	0.080	0.5	0.025
Arsenic	mg/L	0.05	MCL	EPA, DHS	<0.01	<0.005	<0.01	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.001	0.002
Barium	mg/L	1. (f)	MCL	DHS	<0.25	<0.25	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.05	0.09	0.07	0.077
Cadmium	mg/L	0.005	MCL	EPA	<0.002	<0.002	<0.002	<0.002	0.000(d)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001
Calcium	mg/L				27.6	32.4	25.6	29.6	28.5	16.9	24.8	27.1	30	26.8	24.2	28.2	30.8	31	31
Chromium	mg/L	0.05 (g)	MCL	DHS	<0.005	<0.01	<0.01	<0.01	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	0.002	<0.001
Copper	mg/L	1.3 (h)	MCL	EPA	0.06	<0.02	0.03	<0.01	0.002	0.002	0.002	<0.001	0.003	0.001	0.006	0.005	0.001	0.006	0.004
Iron	mg/L	0.3	SMCL	EPA, DHS	0.25	<0.08	0.04	0.02	0.064	0.006	0.23	0.02	0.08	0.132	0.038	0.039	0.133	0.22	0.025
Lead	mg/L	0.015 (h)	MCL	EPA	<0.02	<0.02	<0.02	<0.02	0.000(d)	<0.001	<0.001	0.001	<0.002	<0.0005	0.004	<0.001	0.001	0.001	<0.001
Magnesium	mg/L				7.3	9.5	9.7	5.4	10.2	7.8	8.3	10.3	10.9	8.8	9.5	11.1	10.9	13	11
Manganese	mg/L	0.05	SMCL	EPA, DHS	<0.005	<0.01	<0.02	<0.02	0.003	<0.001	0.014	0.002	0.004	0.007	0.007	5.4	0.006	0.03	0.004
Mercury	mg/L	0.002	MCL	EPA, DHS	<0.0005	<0.0005	<0.0005	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.001	<0.0005	<0.001	<0.002	<0.001	<0.001	<0.0002
Potassium	mg/L				1.9	2.1	1.70	1.7	1.5	1.4	1.6	1.3	1.4	1.4	1.5	1.6	1.7	2.0	2.1
Selenium	mg/L	0.01 (i)	MCL	DHS	<0.0025	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.001	<0.002
Silver	mg/L	.05 (j)	MCL	DHS	<0.005	<0.003	<0.01	<0.01	0.00 (d)	<0.001	<0.001	<0.001	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.001	NS
Sodium	mg/L	20. (k)	SMCL	EPA	9.6	11.8	10.1	10.7	8.9	10.4	8.8	10.8	13.6	9.6	11.8	12.7	14.5	17	13.2
Zinc	mg/L	5.	SMCL	EPA, DHS	0.003	<0.005	<0.02	<0.02	0.001	<0.001	0.001	<0.001	<0.001	0.004	0.006	<0.001	0.005	0.001	0.004

Notes:

(a) Annual sampling, as listed in SFWD water quality reports submitted to DHS.
(b) Action level based on 95% of samples.
(c) DHS limit: 1.4-2.4 mg/l MCL, depending on temperature. EPA limits: 4 mg/l MCL; 2 mg/l SMCL. Applies to naturally occuring fluoride.
(d) No detection limit reported.
(e) EPA limit: 0.05-0.2 mg/l SMCL.
(f) EPA limit: 2 mg/l MCL.
(g) EPA limit: 0.1 mg/l MCL.
(h) Action level based on 90% of samples.
(i) EPA limit: 0.05 mg/l MCL.
(j) EPA limit: 0.1 mg/l SMCL.
(k) Not really a secondary standard, but recommended for people on severely restricted diets.
(NS) Not sampled.

TABLE 5-10

SAN ANTONIO RESERVOIR
ANNUAL MONITORING REPORTS (a)

1978 to 1992

Parameters	units	Drinking Water Standards limit	type	Regulatory Authority	Sampling Date 4/21/78	6/14/79	6/25/80	4/8/81	10/20/82	7/26/83	1/31/84	9/18/84	10/23/85	11/14/86	9/21/87	9/6/88	8/29/89	9/12/90	9/24/91	9/16/92
Physical Characteristics																				
Alkalinity	mg/L				71	65	73.0	115	86	104	105	117	120	111.7	135	57.6	61	69	92	96
Bicarbonate	mg/L				87	78.5	83.0	140	49	112	106	134.4	144	135	164.7	69.8	71.7	NS	NS	NS
Carbonate	mg/L				0	0	0.9	0	1.2	3.1	0	3.7	1.4	0.5	0.0	0	1.3	NS	NS	NS
Color	units	15.	SMCL	EPA, DHS	10	0	0	0	0	10	0	10	0	25	10	0	5	0	25	NS
Conductivity	μmho/cm				368	234	224	316	232	296	301	347	351	334	390	190	173	192	470	505
Hardness	mg/L				94	79.6	100.0	138	102	114	119	134	140	127	153.7	70.0	69	77	116	128
pH	units	6.5-8.5	SMCL	EPA	7.7	8.0	8.4	8.1	8.4	8.7	8.1	8.7	8.3	7.9	8.3	7.8	8.6	8.5	8	8.3
Total ABS					0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.02	NS	NS	NS	NS	NS
'otal Dissolved Solids (TDS)	mg/L	500.	SMCL	EPA, DHS	204	133.8	164	215	145	176	179	204	210	191	227	114	104	115	282	303
Turbidity	NTU	0.5 (b)	MCL	EPA, DHS	3.2	0.95	0.31	0.4	0.9	1.0	3.9	1.2	0.9	1.2	12.8	1.0	2.1	0.4	2.6	1.5
Inorganics																				
Boron	mg/L				0.17	0.14	0.17	0.28	0.17	0.18	0.17	0.14	0.27	0.2	0.6	0.4	0.2	0.2	0.3	NS
Chloride	mg/L	250.	SMCL	EPA, DHS	52	27.8	26	25	7	15	16.0	18.0	24	16.8	22.2	5.3	6.1	10	55	81
Dissolved Oxygen	mg/L				5.9	9.2	8.6	9.7	8.8	8.2	10.2	8.9	8.2	8.0	10.0	8.3	9.2	NS	NS	9.0
Fluoride	mg/L	1.4-2.4(c)	MCL	EPA	0.12	0.07	0.08	0.11	0.10	0.03	0.17	0.11	0.18	0.1	0.15	0.08	0.10	0.10	NS	0.1
Hydroxide	mg/L				0	0	0.0	0	0	0	0	0	0	<0.2	0.0	NS	NS	NS	NS	NS
Nitrate	mg/L	10.	MCL	EPA, DHS	2.9	2.2	0.34	2.5	0.31	1.6	2.6	1.8	3.3	1.7	1.3	0.00 (d)	0.3	<0.1	<0.4	<0.4
Nitrite	mg/L	1.	MCL	EPA	0.003	<0.003	<0.001	0.005	0.001	<0.002	0.001	0.004	<0.001	0.004	<0.003	0.02	0.003	<0.01	<0.4	<0.3
Phosphate	mg/L				0.25	0.20	0.04	0.1	0.05	<0.05	0.16	<0.05	0.04	<0.01	<0.001	0.018	0.005	<0.01	<0.025	NS
Silica	mg/L				7	1.6	6.0	5.3	2.5	5.5	8.7	8.4	5.2	3.3	5.8	NS	1.5	1.1	14	NS
Sulfate	mg/L	250.	SMCL	EPA, DHS	22	16.3	21.0	31	19.5	24.0	24.2	23.9	33.4	21.6	33	20.9	13.9	15	35	38
Metals																				
Aluminum	mg/L	1. (e)	MCL	DHS	0.06	<0.05	0.02	0.1	<0.10	0.04	0.01	<0.01	<0.02	0.03	0.11	0.08	0.103	0.07	0.058	0.11
Arsenic	mg/L	0.05	MCL	EPA, DHS	0.01	<0.005	<0.01	0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.001	<0.005	0.002
Barium	mg/L	1. (f)	MCL	DHS	0.25	<0.25	<0.50	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.05	0.07	0.06	0.08	0.084
Cadmium	mg/L	0.005	MCL	EPA	0.002	<0.002	<0.002	0.002	0.00 (d)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0001
Calcium	mg/L				23	16.4	27.2	37	24.4	18.3	29.7	30.1	32	21.8	36.4	18.0	18.2	20	45	27
Chromium	mg/L	0.05 (g)	MCL	DHS	0.005	<0.01	<0.01	0.01	0.001	0.001	<0.001	0.001	<0.001	<0.001	0.002	0.001	<0.001	<0.001	<0.005	0.002
Copper	mg/L	1.3 (h)	MCL	EPA	0.01	<0.02	0.02	0.01	0.002	0.003	0.003	<0.001	0.004	0.001	0.010	0.003	<0.001	0.02	0.013	0.025
Iron	mg/L	0.3	SMCL	EPA, DHS	0.14	<0.008	0.04	0.02	0.061	0.036	0.21	0.05	0.05	0.129	0.04	0.068	0.204	0.14	0.06	0.10
Lead	mg/L	0.015 (h)	MCL	EPA	0.02	<0.02	<0.02	0.02	0.000(d)	<0.001	<0.001	<0.001	<0.002	<0.0005	0.003	<0.001	<0.001	<0.001	<0.005	0.002
Magnesium	mg/L				8.6	9.4	7.5	11.2	9.8	9.8	11.0	14.3	14.6	17.6	15.2	6.1	5.7	7	1	15
Manganese	mg/L	0.05	SMCL	EPA, DHS	0.005	<0.01	<0.02	0.02	0.007	0.002	0.013	0.005	0.008	0.014	0.036	5.6	0.006	0.02	0.006	0.003
Mercury	mg/L	0.002	MCL	EPA, DHS	0.0005	<0.0005	<0.0005	0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.001	<0.0005	<0.001	<0.002	<0.001	<0.001	<0.0002	<0.0002
Potassium	mg/L				2.4	1.9	1.47	2	1.6	1.7	2.7	1.9	2	1.8	2.4	1.2	1.3	1.5	3.7	3.4
Selenium	mg/L	0.01 (i)	MCL	DHS	0.0025	<0.005		0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.001	<0.005	<0.002
Silver	mg/L	0.05 (j)	MCL	DHS	0.005	<0.003	<0.01	0.01	0.000	<0.001	<0.001	<0.001	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NS
Sodium	mg/L	20. (k)	SMCL	EPA	30	18.9	13.9	18.9	12.3	15.4	13.0	17.6	23.2	15.8	22.3	7.8	8.0	9.2	40	54.2
Zinc	mg/L	5.	SMCL	EPA, DHS	0.009	<0.05	<0.02	0.02	0.000(d)	<0.001	0.001	0.002	0.002	0.001	0.014	<0.001	0.009	0.002	0.006	0.049

Notes:

(a) Annual sampling, as listed in SFWD water quality reports submitted to DHS.

(b) Action level based on 95% of samples.

(c) DHS limit: 1.4-2.4 mg/l MCL, depending on temperature. EPA limits: 4 mg/l MCL; 2 mg/l SMCL. Applies to naturally occuring fluoride.

(d) No detection limit reported.

(e) EPA limit: 0.05-0.2 mg/l SMCL.

(f) EPA limit: 2 mg/l MCL.

(g) EPA limit: 0.1 mg/l MCL.

(h) Action level based on 90% of samples.

(i) EPA limit: 0.05 mg/l MCL.

(j) EPA limit: 0.1 mg/l SMCL.

(k) Not really a secondary standard, but recommended for people on severely restricted diets.

(NS) Not sampled.

TABLE 5-11

ALAMEDA WATERSHED PATHOGEN STUDIES

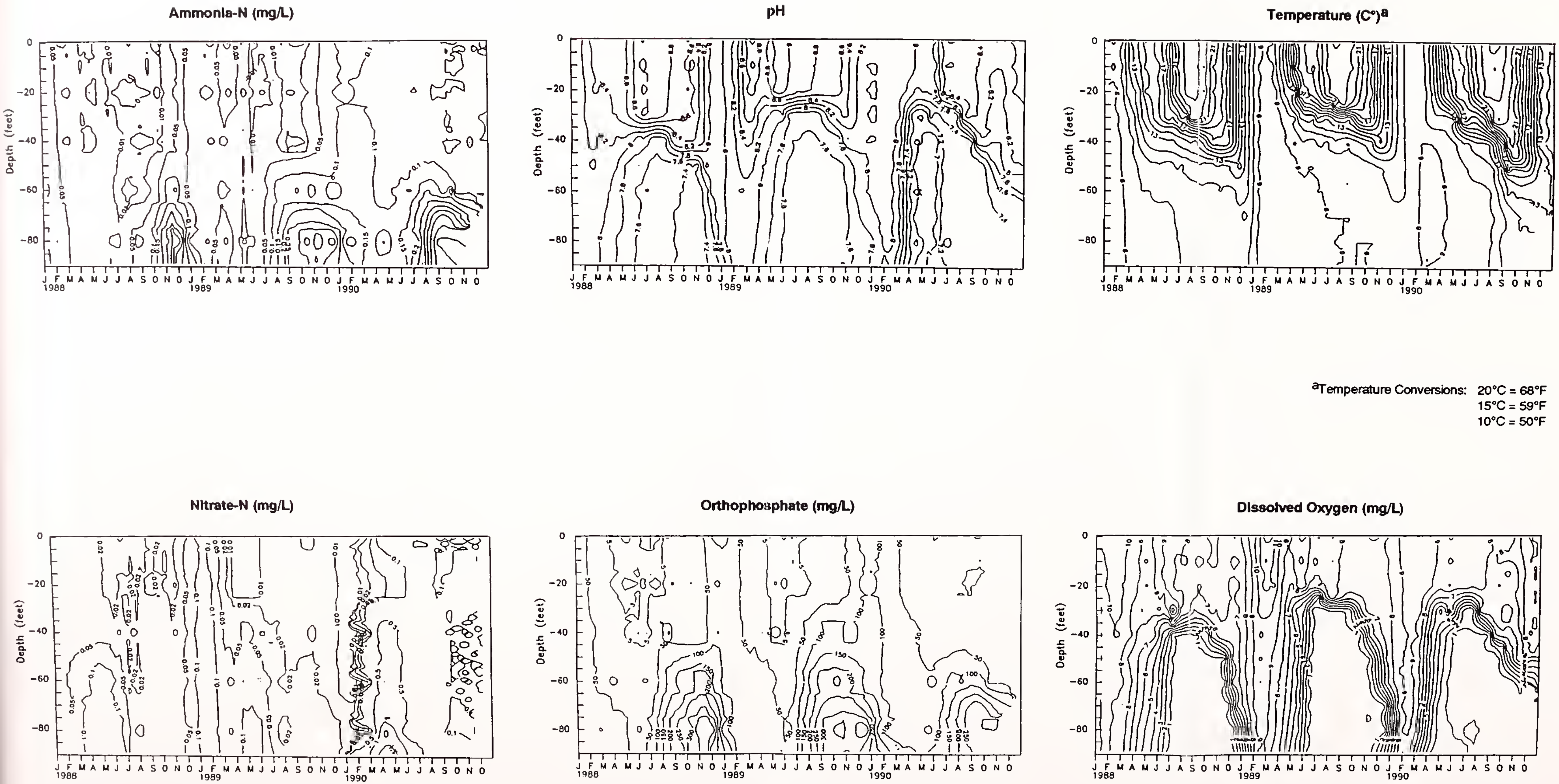
January 1993 to January 1994

	Calaveras Reservoir					San Antonio Reservoir				
Date	turbidity (a) (NTU)	total coliform (MPN)	fecal coliform (MPN)	Giardia lamblia (cysts/ 100 L)	Cryptosporidium (oocysts/ 100 L)	turbidity (a) (NTU)	total coliform (MPN)	fecal coliform (MPN)	Giardia lamblia (cysts/ 100 L)	Cryptosporidium (oocysts/ 100 L)
1/4/93	20.0	350	49	<0.3	<0.3	6.4	79	17	<0.3	<0.3
1/19/93	NS	NS	NS	<0.3	<0.3	1.6	<1,600	NS	<0.3	0.5
2/1/93	2.5	33	2	<0.3	<0.3	0.6	2	2	<0.3	<0.3
2/16/93	9.7	140	8	<0.3	<0.3	0.6	14	7	<0.3	<0.3
3/1/93	13.0	31	23	<0.3	<0.3	23.0	31	5	<0.3	<0.3
3/15/93	3.3	7	<2	0.3	<0.3	17.2	26	5	<0.3	<0.3
3/29/93	2.3	79	33	<0.3	0.3	13.2	2	<2	<0.3	<0.3
4/12/93	1.6	11	2	<0.3	<0.3	12.1	14	<2	<0.3	<0.3
4/26/93	1.8	<2	<2	<0.3	<0.3	13.6	<2	<2	<0.3	<0.3
5/10/93	0.7	9	<2	<0.3	<0.3	7.8	<2	<2	<0.3	<0.3
5/24/93	1.3	<2	<2	<0.3	<0.3	6.0	2	2	<0.3	<0.3
6/7/93	0.7	<2	<2	<0.2	0.2	6.1	2	<2	<0.2	<0.2
6/21/93	0.1	17	8	<0.3	<0.3	5.0	2	<2	0.8	0.3
7/6/93	0.5	<2	<2	<0.2	0.2	3.9	<2	<2	<0.3	0.3
7/19/93	0.7	<2	<2	0.5	<0.2	3.6	<2	<2	<0.3	1.2
8/2/93	0.5	<2	<2	<0.2	0.2	3.1	5	<2	0.5	<0.2
8/18/93	1.4	NS	NS	<0.3	<0.3	2.6	NS	NS	<0.3	<0.3
8/30/93	1.0	<2	<2	<0.3	<0.3	1.6	<2	<2	<0.2	<0.2
9/13/93	0.7	<2	<2	<0.2	<0.2	1.3	2	2	<0.3	<0.3
9/27/93	1.5	5	2	<0.2	<0.2	1.9	<2	<2	<0.3	<0.3
10/12/93	0.5	<2	<2	<0.2	<0.2	2.0	<2	<2	<0.2	<0.2
10/25/93	1.1	4	<2	<0.3	0.3	1.1	4	<2	<0.3	<0.3
11/9/93	1.5	11	2	<0.3	<0.3	0.5	5	<2	<0.3	<0.3
11/23/93	0.3	2	<2	<0.3	<0.3	0.5	2	<2	0.3	0.8
12/7/93	1.2	<2	<2	<0.3	<0.3	0.5	<2	<2	<0.3	<0.3
12/21/93	0.5	11	5	<0.2	<0.2	0.6	2	<2	<0.2	<0.2
1/4/94	1.3	5	2	<0.2	<0.2	1.2	<2	<2	<0.2	<0.2
1/26/94	1.2	110	12	<0.3	0.7	2.2	8	<2	<0.2	0.2

Source: SFWD, 1994

(a) Turbidity, while not a measure of pathogens, was included in this sampling program to determine if any correlation between turbidity and pathogens exist.

NS: Not Sampled



[a]Temperature Conversions: 20°C = 68°F
15°C = 59°F
10°C = 50°F

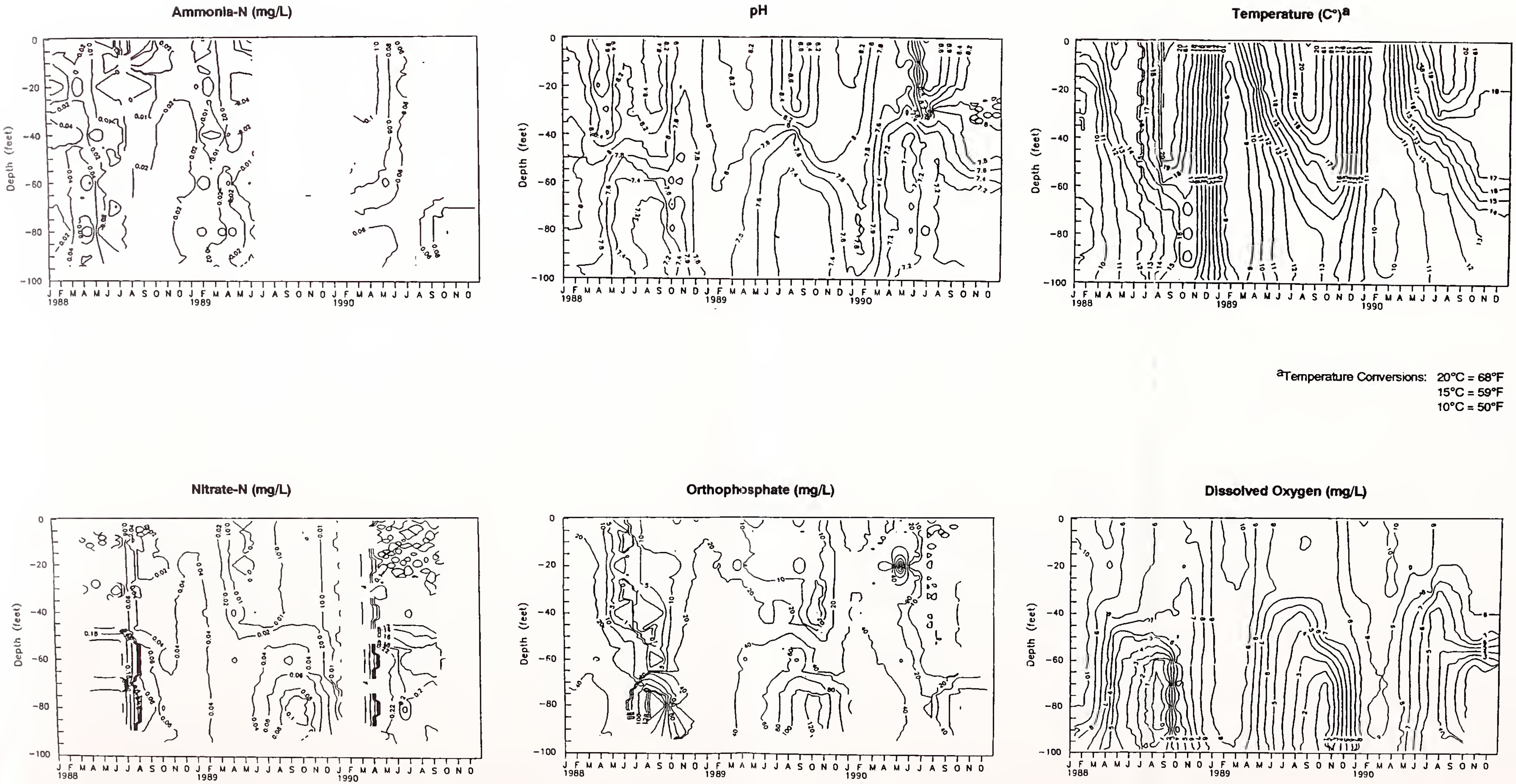
Source: SFWD Lab Data Sheets, 1993.

637.0070 CRJ 2/94

MONTGOMERY WATSON

CALAVERAS RESERVOIR LIMNOLOGY
DEPTH PROFILES & ISOPLETHS
1988 - 1990

FIGURE 5-5



[a]Temperature Conversions: 20°C = 68°F
15°C = 59°F
10°C = 50°F

Source: SFWD Lab Data Sheets, 1993.

637.0070 CRJ 2/94

MONTGOMERY WATSON

SAN ANTONIO RESERVOIR LIMNOLOGY
DEPTH PROFILES & ISOPLETHS
1988 - 1990

FIGURE 5-6

Alkalinity in Calaveras Reservoir averages 99.6 mg/L, remaining relatively stable with a standard deviation of 13.9 mg/L. San Antonio averages a similar concentration at 95.1 mg/L, but experiences much wider fluctuations with a standard deviation of 40.6 mg/L. The same pattern is true for hardness and conductivity in the two reservoirs. Calaveras Reservoir averages hardness levels of 110.4 mg/L, with a standard deviation of 18.5 mg/L. San Antonio has a similar average, 109.8 mg/L, but the standard deviation is 47.5 mg/L. Specific Conductance in Calaveras Reservoir averages 247.1 µmho/cm with a standard deviation of 37.6 µmho/cm. The mean measurement for San Antonio is 270.9 µmho/cm, standard deviation at 109.3 µmho/cm.

The water in San Antonio Reservoir measures, on average, 25 mg/L of chloride, 25 mg/L of sulfate, and 180 mg/L of TDS. Sodium averages 20 mg/L, which is the maximum daily concentration EPA recommends for individuals on severely restricted diets. Calaveras water typically has somewhat lower concentrations, averaging 12 mg/L sodium, 9 mg/L chloride, 18 mg/L sulfate, and 150 mg/L TDS. The higher concentrations in San Antonio Reservoir result from the introduction of Delta water through the State Water Project.

Metals. Tables 5-9 and 5-10 present the trace metal concentrations of raw waters of Calaveras and San Antonio Reservoirs. With one exception. the measured concentrations were low or undetected. The sole exception occurred in 1988, when every manganese sample for both reservoirs was two to three orders of magnitude higher than typical measurements, most likely indicating an erroneous reading. SFWD has initiated annual sampling for the following Phase V metals: antimony, beryllium, nickel, and thallium, as required by DHS.

Microbiology. SFWD samples for coliform, and reports results in percent positive samples. The WQPS reported that coliform bacteria were typically less than a few hundred per 100 mL in the Alameda reservoirs. Both reservoirs exhibited seasonal trends, with elevated counts during the wet weather months. Between February and April, San Antonio averaged between 44 and 54 percent positive. During summer months, coliform levels declined steadily from approximately 39 percent positive in May to a low in September. under 30 percent positive. (WQPS, SFWD 1990)

In 1986, 36 cattle grazing within the Alameda watersheds were tested for *Giardia lamblia* and found negative. Tributary streams flowing into both reservoirs were also tested, and in all cases were found negative, with one exception of a sample collected at the diversion dam from Alameda Creek to Calaveras Reservoir. (WQPS, SFWD 1990)

In December 1989, Alameda reservoirs were again tested for *Giardia lamblia* and *Cryptosporidium.* No evidence of *Giardia* was found. Sampling at Calaveras yielded positive results for *Cryptosporidium* at 0.05 and 0.02 oocysts/100L, while the San Antonio tests for *Cryptosporidium* were negative. (WQPS, SFWD 1990)

In 1993, SFWD conducted another round of sampling for pathogens in the Alameda Watershed as shown in Table 5-11. Two Calaveras *Giardia* tests were positive, at 0.3 and 0.5 cysts/100L. Six *Cryptosporidium* tests were positive, with three results measuring 0.2, two at 0.3, and one at 0.7 oocysts/100L. Fecal coliform counts ranged from <2 MPN from April to September to a high of 49 MPN in January. Total coliform followed a similar seasonal pattern, reaching a maximum of 350 MPN in January.

In 1993, monitoring results from San Antonio Reservoir included three samples with *Giardia* at 0.8, 0.5, and 0.3 cysts/100L. *Cryptosporidium* tests yielded five positives, ranging from 0.3 to 1.2 oocysts/100L. Fecal coliform tests were generally <2 MPN between April and September, with a maximum of 17 MPN in January. Total coliform tests indicated <2 MPN or 2 MPN after April, peaking at >1,600 in January.

SFWD staff have logged algal blooms and copper sulfate applications throughout the Alameda watershed since 1932. Each notation includes the date, dosage, and identifies the problematic algae. Table 5-12 summarizes the algae listed between 1980 and 1993. In 1977, after water was transferred from the State Water Project, SFWD records indicate that San Antonio Reservoir experienced unprecedented algal blooms.

A primary concern of the SWTR is the risk to public water supplies from pathogens. These microbiological sampling results and their implications are discussed in more detail in the subsequent section entitled *Evaluation of the System's Ability to Meet the SWTR.*

TABLE 5-12

ALAMEDA WATERSHED RECORDED ALGAL POPULATIONS

1980 to 1993

Algal Species	Algal Type	Water Quality/ Treatment Concern
Asterionella	diatom	taste and odor algae
Anabaena	blue-green	taste and odor algae
Aphanizomenon	blue-green	taste and odor algae
Ceratium	blue-green	taste and odor algae
Cyclotella	diatom	filter-clogging algae
Dinobryon	blue-green	taste and odor algae
Fragillaria	diatom	filter-clogging algae
Mallomonas	blue-green	taste and odor algae

Source: SFWD, 1994

Organics. SFWD provided monitoring data for organic compounds collected on October 13, 1993, as presented in Appendix B. On the basis of this data, all Alameda samples were below detection limits for all parameters.

SFWD has been monitoring organics and inorganics prior to the promulgation of Phase II and Phase V rules. Consequently, SFWD requested waivers from DHS for the SOCs and VOCs included in the Phase II and Phase V regulations. The requests were made on the basis of current waivers, grandfathering, use, or susceptibility. Using historical monitoring data as evidence, in the waiver requests SFWD proposed monitoring VOCs on an annual rather than quarterly basis. See Tables 5-4 and 5-5.

Asbestos. SFWD tested for asbestos in 1979, 1980, 1984, and 1993, as presented in Table 5-13. Current drinking water regulation (7 MFL) targets only the long fibers greater than 10 μm in length which are associated with health-related concerns. These health-related concerns pertain to airborne fibers which, from a drinking water perspective, would occur during activities such as showering or use of a vaporizer. In Calaveras Reservoir, the results for total fibers (short and long fibers) were 61.7, 35, and 11.7 MFL for the first three dates. In 1993, SFWD tested for long fibers only, with the results being <0.49 MFL, which is below the drinking water standard. San Antonio Reservoir was tested in 1979, 1980, and 1993. The results for total fibers were 0.36 and 0.074 MFL, and for long fibers <0.19 MFL, respectively.

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

TABLE 5-13

ALAMEDA ASBESTOS CONCENTRATIONS
RAW AND TREATED WATER

1979 to 1993

Location	Sample Date	Concentration (MFL) (a)	MCL (MFL) (b)
Calaveras Reservoir			
	21-Jun-79	61.7	
	10-Oct-80	35	
	18-Sep-84	11.7	
	13-Oct-93	<0.49	
San Antonio Reservoir			
	14-Jun-79	0.36	
	10-Oct-80	0.074	
	13-Oct-93	<0.19	
Sunol Water Treatment Plant			
	18-Sep-84	<0.3	7
	13-Oct-93	<0.19	7

Sources: Annual monitoring reports submitted to DHS.
Special Studies, 1993.
MFL: Million fibers per liter
(a) Sampling prior to 1993 was for total fibers. 1993 sampling was for long fibers, greater than 10μm in length.
(b) Current regulations pertain to long fibers only--which are the fibers associated with health-based concerns.

Radionuclides. At the end of 1993, SFWD initiated a year of quarterly sampling for radionuclides, with the approval of DHS. Table 5-14 presents historical information, as well as more recently collected data. In 1994, a new deadline will be set for the final rule.

Disinfectant/Disinfection By-Products (D/DBPs). A discussion of D/DBPs can be found in this section entitled *Evaluation of the System's Ability To Meet the SWTR.* SFWD has sampled THMs, a measurement of four D/DBPs, since 1979. *Comparison of Raw/Treated Waters To Standards* reviews the sampling results throughout the distribution system from 1989 through 1993, and the data demonstrates compliance with current drinking water standards.

TABLE 5-14

ALAMEDA RADIONUCLIDE CONCENTRATIONS
RAW AND TREATED WATER

(pCi/L)

Location	Date	Gross Alpha		Gross Beta		Radium 226		Radium 228		Radon 222		Strontium 90		Tritium		Uranium
		Sample	Counting Error	Sample	Counting Error	Sample	Counting Error	Sample	Counting Error	Sample	Counting Error	Sample	Counting Error	Sample	Counting Error	Sample
Calaveras Reservoir																
	21-Jun-79	<2		<3		NS		NS		NS		<1		<1000		NS
	15-Nov-93	0	2	3	1	NS		NS		0	16	0	1	0	330	2.4
																0.4
San Antonio Reservoir																
	14.June.79	<2		<3		NS		NS		NS		<1		<1000		NS
	15-Nov-93	1	1	4	1	NS		NS		0	20	0	1	0	320	0.3
																0.1
Sunol WTP																
	15.Nov.93	0	2	1	1	NS		NS		0	19	0	1	0	320	0.1
																0.02

Sources: Annual report submitted to DHS, 1979; special study, 1993.
Notes:
NS: Not Sampled

D/DBP monitoring is not conducted, nor required, for raw water. D/DBPs are included in Phase VIA parameters. EPA published the proposed rule in July, 1994. SFWD plans to begin monitoring for these parameters in October, 1994 throughout the drinking water distribution system.

Limnology

The SFWD profiles water quality in the Alameda Watershed reservoirs a number of times per year. This monitoring program has been in existence since the 1960's. Table 5-15 indicates the number of profiles conducted each year by the SFWD.

When compiling and plotting depth profiles, algorithms interpolate between known data values to construct isopleths, or contours of equal concentration. As the number of data points increase, the reliability and precision of the graphs improve. January 1988 to December 1990 form the basis of the analysis because of the high numbers of profiles conducted during this time span, as shown in Table 5-15. However, because of drought conditions, these profiles exhibit exceptionally strong seasonal patterns and stratification.

Figures 5-5 and 5-6 show evidence of thermal stratification, seasonal overturn, algal growth, nutrient uptake, and dissolved oxygen depletion in Calaveras and San Antonio Reservoirs, respectively. Other parameters for which the results showed less clear or consistent patterns are included in Appendix C: alkalinity, conductivity, chlorides, hardness, iron, manganese, nitrite, sulfate, TOC, and turbidity.

Calaveras Reservoir exhibits strong seasonal trends in temperature, dissolved oxygen, and pH, as shown in Figure 5-5. In the winter months of January and February, the reservoir is isothermal, with a uniform temperature of approximately 9°C throughout the water column. Thermal stratification begins in March and lasts until November, when the reservoir turns over. During the hot summer months, the surface reaches 23°C, while the bottom temperature remains constant, hovering around 10°C. The maximum vertical temperature gradient, or thermocline, is approximately 30 feet below the surface.

The thermocline separates the reservoir into two horizontal elements - epilimnion and hypolimnion - with little vertical mixing. Photosynthesis and surface aeration in the upper epilimnion produce dissolved oxygen concentrations of 9 mg/L. At the same time, respiration and microbial degradation of organic matter below the thermocline deplete the dissolved oxygen

CALAVERAS RESERVOIR[a]

Parameter*	Year 1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Alkalinity	5	9	11	5	23	40	33	28	4	4	5
Ammonia	0	0	0	0	20	35	32	23	4	0	0
Chloride	4	9	12	5	23	40	32	27	5	4	5
Conductivity	6	9	12	6	23	40	33	28	5	4	5
D.O.	6	9	11	5	23	38	31	26	4	4	5
Hardness	5	9	11	5	23	40	33	28	4	4	5
Iron	0	0	0	0	0	0	0	0	0	2	1
Manganese	0	0	1	0	0	0	0	10	0	1	1
Nitrate	1	7	3	0	21	30	33	16	5	1	2
Nitrite	0	0	0	0	0	0	0	0	4	0	0
O-Phosphorous	1	3	1	0	21	36	33	24	4	3	5
pH	6	9	12	6	23	40	32	28	5	4	5
Sulfate	0	7	0	0	0	0	0	12	4	0	0
TOC	0	0	1	0	0	35	19	24	5	4	5
Temperature	6	9	12	6	23	40	32	26	4	4	5
Turbidity	6	9	12	6	23	40	33	28	5	4	5

[a]Each profile reflects grab sampling at up to 15 depths

SAN ANTONIO RESERVOIR[b]

Parameter*	Year 1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Alkalinity	2	11	7	4	10	11	11	13	16	15	3
Ammonia	0	0	0	0	7	9	11	9	13	8	1
Chloride	2	11	7	4	10	11	11	13	14	15	3
Conductivity	5	11	7	5	10	11	11	13	16	15	3
D.O.	5	11	6	4	10	10	11	13	15	15	3
Hardness	2	11	7	4	10	11	11	13	16	15	3
Iron	0	0	0	0	0	0	0	0	0	0	0
Manganese	0	0	0	0	0	0	0	0	0	0	0
Nitrate	0	11	0	0	6	6	11	6	10	5	0
Nitrite	0	0	0	0	0	0	0	0	6	0	0
O-Phosphorous	0	9	0	0	6	6	11	10	15	14	2
pH	5	11	7	5	10	11	10	13	16	15	3
Sulfate	0	10	0	0	0	0	0	5	9	0	0
TOC	0	0	1	0	0	10	5	10	14	13	3
Temperature	5	11	7	5	10	11	11	13	15	15	3
Turbidity	5	11	7	5	10	11	11	13	16	15	3

[b]Each profile reflects grab sampling at up to 15 depths

NUMBER OF RESERVOIR WATER QUALITY PROFILES SAMPLED ALAMEDA WATERSHED SYSTEM 1983 - 1993

TABLE 5-15

Source: SFWD Lab Data Sheets, 1993.

to 1 mg/L in June; the hypolimnion becomes anoxic from July to November. When the hypolimnion becomes anoxic, iron, manganese, and other chemicals may be released from the sediment to the water column. These water quality concerns form the basis for the reservoir operating criteria which stipulate that water should be withdrawn from the reservoirs at the depth which minimizes phytoplankton concentrations and maximizes dissolved oxygen.

Ammonia, nitrate, orthophosphate, and pH also show evidence of seasonal trends which may be related to algal growth. Algal dynamics are a function of nutrient levels, and influence pH. Calaveras Reservoir receives runoff from its catchment area, Arroyo Hondo and Calaveras Creek, and diversions from Alameda Creek. Surface runoff occurs almost entirely during wet weather months, carrying large amounts of suspended organic materials and nutrients which can support algal growth. Conversations with staff indicate that during anoxic conditions, release of micronutrients from sediments supplement the winter nutrient input.

At the end of the wet weather season, the water contains approximately 100 µg/L of ammonia nitrogen, 100 µg/L of nitrate nitrogen, and 100 µg/L of phosphorus. Consequently, the nitrogen to phosphorus ratio is 2 to 1 by weight. Since algae consume more nitrogen than phosphorus (12 to 1) to synthesize their biomass, one would expect nitrogen to run out before phosphorus. The plots in Figure 5-5 suggest that nitrogen may have been exhausted on the lake surface in the summer months, while phosphorus is depleted to 5 µg/L. However, some algal species, including blue-green algae, are able to fix nitrogen from the atmosphere to supplement the nitrogen requirement. Because of algal uptake of carbon dioxide, the pH of the epilimnion is raised to about 9 in the summer. During the same time period, the pH of hypolimnion remains between 7.2 and 7.6.

During January and February, the temperature of San Antonio Reservoir is approximately 9°C throughout the water column. Stratification begins in April and overturn occurs in October or November, depending on the specific weather conditions of any given year. The thermocline in San Antonio Reservoir occurs at 20 to 30-foot depth, and is less distinct than the sharp temperature gradient observed in Calaveras Reservoir. There is also less variation in temperature during the summer months in San Antonio Reservoir than Calaveras Reservoir. The surface temperatures of San Antonio Reservoir reach 21°C and the hypolimnion measures 12°C, as compared to Calaveras measurements at 23°C and 9°C, respectively. During the summer, dissolved oxygen reaches 9 mg/L in the epilimnion and is as low as 1 mg/L in the hypolimnion. The hypolimnion in San Antonio Reservoir generally remains aerobic.

Source waters supplying San Antonio Reservoir currently include local runoff during the winter rainy season, as well as transfers from the Hetch Hetchy pipeline, Calaveras releases, and during the recent drought, emergency supplies from the South Bay Aqueduct. Therefore, nutrient input can occur throughout the year. In the early spring before stratification, nutrient levels range around the following: 80 µg/L of ammonia nitrogen, 80 µg/L of nitrate nitrogen, and 20 µg/L of phosphorus. The nitrogen to phosphorus ratio is approximately 8 to 1. After stratification, algal growth depletes the nutrient concentration to 20 µg/L of ammonia nitrogen, 20 µg/L of nitrate nitrogen, and 10 µg/L of phosphorus. The nitrogen to phosphorus ratio is 4 to 1. While there is a general perception of reduced water quality in San Antonio Reservoir because of the Delta water, it appears that the reservoir has a higher nitrogen to phosphorus ratio than Calaveras Reservoir. The nutrient conditions in San Antonio Reservoir are less conducive to nitrogen-fixing blue-green algae than Calaveras Reservoir. One would expect fewer nitrogen-fixing blue-green algae in San Antonio Reservoir. The SFWD confirmed that there is a greater algae problem in Calaveras than in San Antonio Reservoir, but both reservoirs have experienced blooms of blue-green algae.

Trends in Water Quality Data

This section reviews historical data for long-term trends which may indicate changes in water quality. In addition, there is a discussion of the role of runoff in contributing pollutants to the watershed.

Time Series Analysis. The water in Calaveras Reservoir is generally of high quality. For nearly all of the water quality parameters, the ranges of concentrations measured in the raw waters are well below the regulatory limits for treated water. Only three parameters have ranges which are close to the limits for treated water: color, pH, and turbidity. SFWD treats the raw waters so as to achieve the drinking water standards. Furthermore, the regulatory limits for color and pH are SMCLs, which are suggested levels concerned with the aesthetics of drinking water, rather than public health concerns. Figure 5-7 displays graphical information and statistical summaries for Calaveras Reservoir.

In San Antonio Reservoir, turbidity, sodium, color, and pH are the only parameters in which the raw water approaches the drinking water standards. For all other constituents, the raw water concentrations are well below the regulatory limits for drinking water. Three parameters exhibited a marked increase in 1991 and 1992, reflecting the impacts of water transfers from the

[illegible]

[illegible]

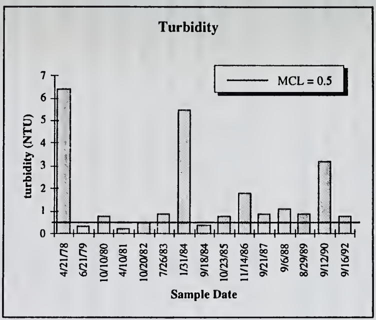
[illegible]

[illegible]

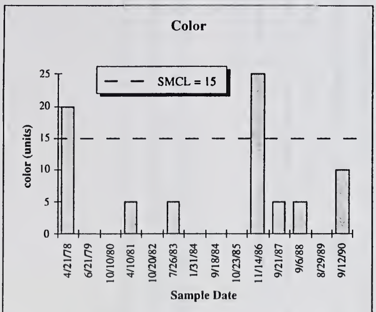
[illegible]

RAW WATER QUALITY-
CALAVERAS RESERVOIR (a)

TIME SERIES AND STATISTICAL SUMMARIES

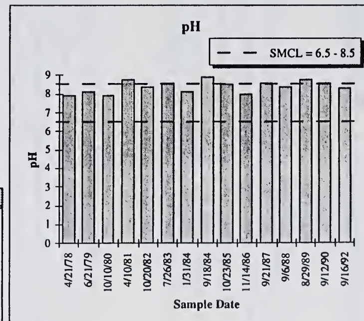


Turbidity	
Mean	1.64
Median	.9
Std Dev'n	1.9
Range	6.15
Minimum	.25
Maximum	6.4
Number	15.



Color	
Mean	5.4
Median	2.5
Std Dev'n	8.
Range	25.
Minimum	0
Maximum	25.
Number	14.

pH	
Mean	8.4
Median	8.4
Std Dev'n	0.3
Range	1.
Minimum	7.9
Maximum	8.9
Number	15.



Sources: SFWD annual reports submitted to DHS.
Special studies.

Note: (a) MCLs and SMCLs apply to treated water, NOT raw water, and are shown in this figure only for relative comparison with raw water quality.

State Water Project: conductivity, chlorides, and sodium. Figure 5-8 depicts the time series and statistical summaries for these six parameters.

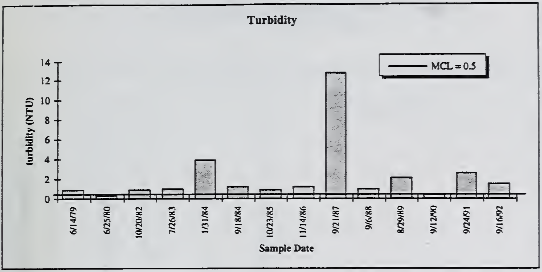
Impacts of Runoff. There are five general source water quality parameter categories which may be impacted by runoff: particulates, microorganisms, D/DBP precursors, nutrients, pesticides/synthetic organic compounds, and metals. Stormwater runoff during wet weather is likely to cause an influx of these parameters into surface water supplies. Adequate data do not exist to correlate runoff with contaminants in the Alameda reservoirs. However, precipitation and turbidity were compared.

Figure 5-9 juxtaposes monthly rainfall data with surface and bottom turbidities in San Antonio Reservoir between 1983 and 1991. The precipitation data was obtained from DWR. The rain gage is located at Calaveras Dam, which receives significantly higher annual rainfall than San Antonio. Surface turbidity levels climb sharply after rainfall events, and attenuate relatively quickly. Bottom turbidities, on the other hand, seem to lag in peaking, and recovery takes an extended period of time. For example, in 1986, peak rainfall occurred in February, yet bottom turbidities at San Antonio remained elevated well into the summer.

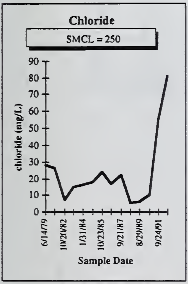
The exact relationship between rainfall, runoff, and the turbidity of the reservoir cannot be determined from the currently available data. Since runoff is suspected of discharging particulates, pathogens, THM and D/DBP precursors, nutrients, and pesticides/synthetic organic compounds into reservoirs, it is important to identify the sources and understand the response and changes in concentration after storm events. Sources of these parameters are being investigated in conjunction with the Watershed Management Plan. The water quality vulnerability zone assessment identified natural sources of constituents which may degrade water quality, while human sources are addressed in Sections Seven and Eight of this WSS. A monitoring program tailored to investigate the relationships between water quality, runoff, and potential sources of degradation may prove instrumental in obtaining the needed information to design effective control strategies and to measure the results.

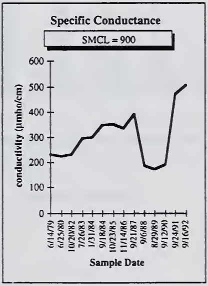
Because the catchment area of the Alameda watershed extends beyond the SFWD lands, contaminants may flow into the reservoirs from lands beyond the SFWD holdings. Sampling at strategic locations after rainfall events will help identify the contribution of contaminants external to SFWD lands.

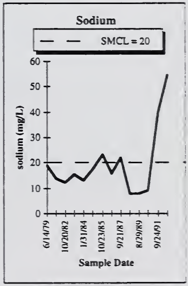
FIGURE 5-8
RAW WATER QUALITY-
SAN ANTONIO WATER QUALITY (a)
TIME SERIES AND STATISTICAL SUMMARIES



Turbidity	
Mean	2.2
Std Dev'n	3.2
Minimum	.3
Maximum	12.8
Range	12.5
Number	14.0



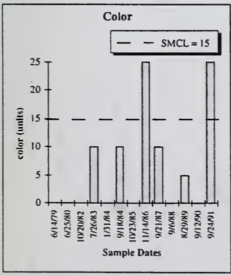




Chloride	
Mean	23.6
Std Dev'n	20.8
Minimum	5.3
Maximum	81.0
Range	75.7
Number	14.0

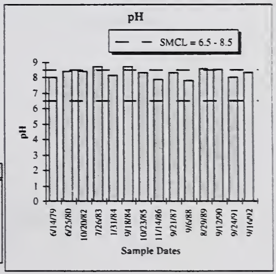
Conductivity	
Mean	302.8
Std Dev'n	103.6
Minimum	173.0
Maximum	505.0
Range	332.0
Number	14.0

Sodium	
Mean	19.4
Std Dev'n	13.0
Minimum	7.8
Maximum	54.2
Range	46.4
Number	14.0



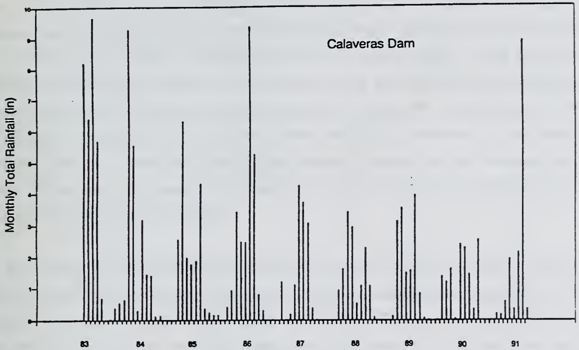
Color	
Mean	6.5
Std Dev'n	9.2
Minimum	.0
Maximum	25.0
Range	25.0
Number	13.0

pH	
Mean	8.3
Std Dev'n	.3
Minimum	7.8
Maximum	8.7
Range	.9
Number	14.0

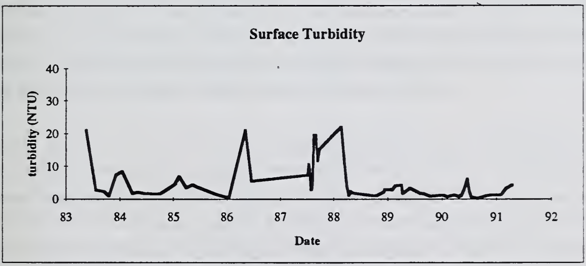


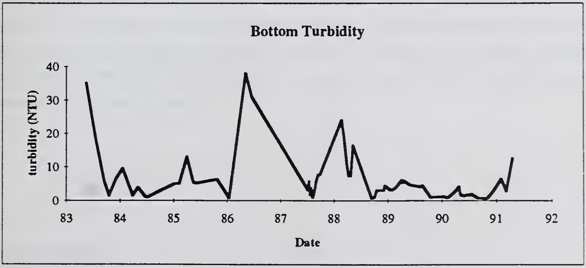
Note: (a) MCLs and SMCLs apply to treated water, NOT raw water, and are shown in this figure only for relative comparison with raw water quality.

FIGURE 5-9
SAN ANTONIO RAINFALL AND TURBIDITY
1983 to 1991

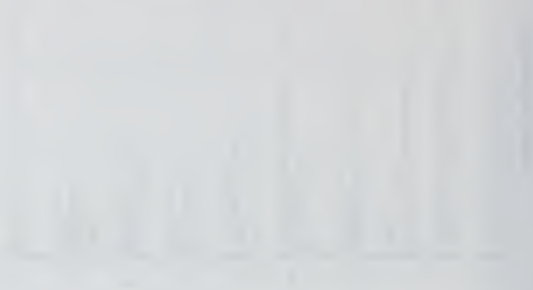


Alameda Watershed Monthly Rainfall (a)





(a) DWR precipitation data. Rain gage at Calaveras Dam.



Comparison of Raw/Treated Water to Standards

The SFWD publishes an annual report, summarizing water quality for the year. The report presents data averaged over the entire SFWD treated water distribution system and spanning the year under review. Table 5-16 presents the 1993 annual report. The ranges and average concentrations listed for treated water parameters are all within the MCLs. However, in the Alameda Watershed there were several parameters in which the concentrations of the raw water approached the drinking water regulatory limits--requiring treatment. Time series graphs and statistical summaries were provided in the previous section, and are discussed in more detail below. Where possible, the raw water quality is compared with post-treatment data to verify that drinking water MCLs are being met.

The raw waters of Calaveras and San Antonio Reservoirs can have high turbidity levels. To remove particulates from the raw waters and achieve drinking water standards, SFWD treats all Alameda watershed water at Sunol WTP. The Sunol WTP treated water turbidity is monitored continuously through on-line turbidimeters and the operations staff monitor the effluent for turbidity levels by collecting grab samples every four hours; a summary is presented in Table 5-17. Between January 1993 and January 1994 the average monthly treated water turbidities ranged from 0.07 to 0.27 NTU. The average monthly removal rate through the plant was 91.1 to 98.2 percent. Treatment plant performance was excellent during this year, with the exception of January 1993 where the effluent turbidity levels were less consistent.

During this period, the Sunol WTP was undergoing construction for modifications, and raw water turbidities were elevated, ranging between 4.9 and 29.4 NTU. In addition, because Calaveras Reservoir had been drawn down for construction, Hetch Hetchy water was being routed to the WTP for blending, resulting in difficult treatment conditions. The treatment plant achieved excellent removal rates during this month, averaging 98.2 percent. However, there were seven incidents when the turbidity exceeded 1.0 NTU. The maximum effluent turbidity was 2.15 NTU. Subsequent testing showed no evidence of microbiological contamination of the drinking water system resulting from these incidents. The seven high turbidity incidents were clearly related to the Sunol WTP construction activities and reflect an operational anomaly. DHS was notified of the occurrence.

Secondary Standards—Aesthetic Standards

PARAMETER	UNIT	MAXIMUM CONTAMINANT LEVEL	TREATED SFWD WATER[1]	
			RANGE	AVERAGE
Chloride	mg/l	250	4-46	17
Color	units	15	0	0
Foaming Agents (MBAS)	mg/l	0.5	ND	ND
Iron	mg/l	0.3	0.023-0.030	0.017
Manganese	mg/l	0.05	<0.005-0.005	<0.005
Odor Threshold	units	3	<1	<1
Specific Conductance	umho/cm	900	44-313	156
Sulfate	mg/l	250	1.7-21	10
Total Dissolved Solids (TDS)	mg/l	500	26-188	94
Zinc	mg/l	5.0	<0.005-0.009	<0.005
Additional Constituents Analyzed				
Alkalinity (CaCO3)	mg/l	no standard	13-69	43
Calcium	mg/l	no standard	2-53	27
Chlorine	mg/l	no standard	0.1-2.1	0.6
Hardness (CaCO3)	mg/l	no standard	14-77	48
pH	mg/l	no standard	7.7-9.2	8.7
Potassium	mg/l	no standard	0.2-1.9	1.1
Sodium	mg/l	no standard	0.7-14	8.6

PURPOSE

The information provided in this report is in compliance with requirements established by the U.S. Environmental Protection Agency and the California Department of Health Services. It is the policy of the San Francisco Water Department (SFWD) to fully inform its customers of the water quality standards and typical concentrations of constituents found in their water.

SOURCE WATER

The majority of water delivered to consumers by the SFWD originates from high Sierra snowmelt in 459 square miles of protected Yosemite National Park watershed. This water is stored in Hetch Hetchy Reservoir and delivered 150 miles to the Bay Area through a series of tunnels and pipelines. The remaining supply—about 15% of the total—is derived from 65,000 acres of SFWD owned and protected watershed located in:

- Alameda and Santa Clara Counties—Calaveras and San Antonio Reservoirs.
- San Mateo County—Crystal Springs, San Andreas and Pilarcitos Reservoirs.

WATER TREATMENT

It is the goal of SFWD to provide water of the highest possible quality to its more than 2.5 million consumers in the Bay Area. Hetch Hetchy water is pH adjusted with lime for corrosion control and disinfected with liquid bleach. In addition to the above treatments, all other sources are filtered at Sunol Valley and San Andreas Water Treatment Plants. Water delivered to San Francisco is fluoridated as mandated by City Charter. Communities north of San Mateo in the SFWD service area also receive fluoridated water.

The 1992 EPA Lead and Copper Rule required that all utilities conduct special monitoring to identify the levels of these contaminants in their drinking water, provide public education about the hazards of lead, and if needed, to conduct studies to identify treatment methods that will minimize lead and copper dissolved in the water. While the last round of lead testing showed that SFWD was under the Federal action limit of 15 parts per billion, a corrosion control study program was initiated to comply with the EPA rule. This will ultimately result in the further reduction of both lead and copper in the water to the lowest practical levels that can be achieved with current technology. The program will also result in maximum corrosion protection for our hundreds of miles of transmission pipelines and reduce the amount of copper that eventually finds its way to the Bay in the form of treated wastewater.

NOTICE TO CUSTOMERS OF THE SAN FRANCISCO WATER DEPARTMENT

Including resale customers in San Mateo, Santa Clara and Alameda Counties.

The San Francisco Water Department (SFWD) and its resale customers represented by the Bay Area Water Users Association (BAWUA) are required by state regulations to advise water users of issues that may impact the quality of their drinking water. The California Department of Health Services (DHS), Office of Drinking Water (ODW) has determined that the Hetch Hetchy water system operated by the City of San Francisco meets the "filtration avoidance" criteria outlined in 40 CFR 1.41.71. In other words, the Hetch Hetchy water supply meets the U.S. Environmental Protection Agency (EPA) criteria for watershed protection, bacteriological quality and operational standards so it does not require water filtration under the State Drinking Water Act Amendments of 1986.

San Francisco's Hetch Hetchy supply in the Sierra Nevada mountains, which represents over eighty percent of the water served to SFWD customers in the four county service area, is served without filtration.

EPA water quality regulations require surface water systems to be filtered unless they meet very strict standards for watershed protection, disinfection treatment and water system operations. EPA and DHS have determined that the SFWD system meets these "filtration avoidance" criteria.

Filtration is considered the treatment of choice for most water systems because it generally reduces the chances of microbiological contaminants entering the drinking water. A few water systems with very high levels of watershed protection and that have been determined to represent minimal biological risk can be treated with disinfection only. Years of water quality data prove that Hetch Hetchy water is well protected, is of very high quality and is safe from pathogens, without filtration.

The SFWD has entered into a compliance agreement with DHS and is continuing to study ways of improving the treatment of drinking water without the expense of a new filtration plant which has an estimated cost of $400–$500 million.

Customer questions on the issue of filtration or any other water quality issues should be directed to the SFWD water quality Division, (415) 872-5942.

For additonal information regarding the quality of your water, please call the Water Quality Division at 872-5942

TABLE 5-17

SUNOL WTP TURBIDITY MONITORING

January 1993 to January 1994

	January	February	March	April	May	June	July	August	September	October	November	December	January
No. of Days Plant In-Service	29	OL	15	10	4	24	29	22	1	25	30	31	31
Raw Water													
Average Turbidity (NTU)	15.4	OL	ND	ND	4	2	1.3	1.2	1.12	1.27	1.1	0.9	1.42
Treated Water													
No. of Samples	171	OL	81	70	27	148	186	139	20	149	180	186	186
No. of Samples < 0.5 NTU	146	OL	79	70	27	148	186	138	20	149	179	186	186
Percent < 0.5 NTU	85.4%	OL	97.5%	100.%	100.%	100.%	100.%	99.3%	100.%	100.%	99.4%	100.%	100.%
Average Monthly Turbidity (NTU)	0.27	OL	0.15	0.12	0.11	0.12	0.11	0.08	0.1	0.077	0.085	0.07	0.067
.verage Monthly Turbidity Reduction	98.2%	OL	ND	ND	97.3%	94.%	91.5%	93.3%	91.1%	93.9%	92.3%	92.2%	95.3%

Source: SFWD operator logs.
OL: WTP Off-Line.
ND: No Data Available.

Raw water from San Antonio Reservoir can exceed the drinking water SMCL for sodium. However, there are no data from Sunol WTP on effluent sodium concentrations.

The Total Coliform Rule (TCR) requires 95 percent of the total coliform samples collected throughout the distribution system must show absence of total coliforms on a monthly basis. Table 5-18 presents the coliform sampling results. From February 1993 to January 1994 only 0 percent to 4 percent of the samples indicated the presence of total coliforms which is within the TCR requirement.

SFWD collects quarterly samples of THMs throughout the distribution system. The concentrations of each sampling event are averaged. Compliance is based on a running average of the past four quarters, and the MCL is 0.10 mg/L. Distribution system samples have met this standard. Table 5-19 presents sampling results from 1989 to 1993. THM levels are within the MCL of 0.10 mg/L.

Projected Changes in Water Quality

There are no changes in water quality anticipated. However, the goal of the Watershed Management Plan project undertaken by the SFWD is to maintain and improve water quality. As management strategies become more effective, SFWD may see improvements in raw water quality in most of the water quality parameter groups. The use of synthetic organic compounds and pesticides within the watershed can be reduced or eliminated, or replaced with more degradable, less toxic alternatives. THM precursors (including all DBP precursors) and nutrients will be the most difficult parameters to effectively control.

EVALUATION OF THE SYSTEM'S ABILITY TO MEET THE SWTR

The SWTR is concerned with protecting public water supplies from pathogenic organisms. This rule stipulated that surface water supplies must undergo a multibarrier treatment to remove and inactivate waterborne pathogens. These requirements were intended to provide consumers with reliable and redundant protection. EPA promulgated rules requiring the removal and inactivation of *Giardia lamblia*, viruses, heterotrophic plate count bacteria, *Legionella,* and turbidity through filtration and disinfection.

TABLE 5-18

SFWD DISTRIBUTION SYSTEM
TOTAL COLIFORM RULE
COMPLIANCE HISTORY

February 1993 to January 1994

	No. of Samples	No. of Positive	Percent Positive	Acute Risk?
1993				
February	302	0	0.0%	No
March	339	0	0.0%	No
April	380	14	3.7%	No
May	324	8	2.5%	No
June	336	3	0.9%	No
July	331	6	1.8%	No
August	340	7	2.1%	No
September	373	15	4.0%	No
October	307	4	1.3%	No
November	338	13	3.8%	No
December	309	2	0.6%	No
1994				
January	326	5	1.5%	No

Source: SFWD report submitted to DHS.

For compliance, at least 95% of the samples must be negative on a monthly basis.

TABLE 5-19

SFWD DISTRIBUTION SYSTEM
TOTAL TRIHALOMETHANES (a)

1989-1993

(mg/L)

Location Code	Sample Point	1989 First Quarter	1989 Second Quarter	1989 Third Quarter	1989 Fourth Quarter	1990 First Quarter	1990 Second Quarter	1990 Third Quarter	1990 Fourth Quarter
		8-Mar	14-Jul	13-Sep	1-Nov	14-Feb	27-Jun	15-Aug	31-Oct
UMS-3	Bay Bridge Pumps	0.046	0.086	0.089	0.083	0.044	0.084	0.078	0.105
UMS-5	Laguna & Lombard	0.047	0.091	0.093 (b)	0.078	0.042 (b)	0.082 (b)	0.076 (b)	0.099
CHS-1	S.F. General Hospital	0.039	.050 (b)	0.081	0.067 (b)	0.041 (b)	0.065	0.053	0.085 (b)
CHS	Shell Station, Bush & Steiner	.044 (b)	0.061	0.082	0.078	0.042	0.054	0.067	0.088
SS-1	42nd Ave & Geary Blvd.	0.043	0.075	0.092 (b)	0.077	0.042	0.062	0.068	0.089
SS	425 Mason Street	0.043 (b)	0.082	0.091	0.083 (b)	0.043	0.068	0.073	0.092
SS-7	Fillmore & Turk	0.044	0.087 (b)	0.103	0.081 (b)	0.043 (b)	0.059	0.078	0.094
PHS	20th St & Missouri	0.035	0.050	0.081 (b)	0.071	0.038	0.044 (b)	0.056 (b)	0.079 (b)
LS	Powell & Jackson (library)	0.049	0.085 (b)	0.090	0.076	0.041	0.064	0.053	0.097
SHO	SHR chlorine Station	0.049	0.091	0.097	0.086	0.045 (b)	0.065	0.062 (b)	0.109
SHS-2	SR Chlorine Station	0.056	0.080	0.081	0.081	0.036	0.063 (b)	0.058	0.094
SHS-3	McAteer High School	0.054 (b)	0.087	0.102	0.087	0.067	0.086	0.083	0.091 (b)
Sutro Out	Olympia & Clarendon	0.055	0.106	0.075	0.058	0.049	0.064 (b)	0.077	0.081
SS	Chevron @ California, bet Taylor & Mason	0.052	0.082 (b)	0.106	0.089	0.038	0.099	0.062	0.093
Sutro Sys-4	Guadalupe School	0.047	0.080	0.078 (b)	0.093	0.037	0.058	0.060 (b)	0.087
McLaren Sys-1	Wilde & Girard	0.056	0.109	0.090	0.095 (b)	0.040	0.088	0.090	0.118 (b)
	Average Quarterly Concentration	**0.0474**	**0.0814**	**0.0894**	**0.0802**	**0.0430**	**0.0690**	**0.0684**	**0.0938**
	Running Average--Most Recent 4 Quarters				**0.0746**	**0.0735**	**0.0704**	**0.0652**	**0.0686**

(Continued)

Source: SFWD report submitted to DHS.

Notes:

(a) EPA and DHS MCL for THMs is 0.10 mg/L. Compliance is based on a running annual average of quarterly samples.
(b) Average of two sample results collected at the same location.
(c) NS: Not sampled.

TABLE 5-19 (Cont'd)

SFWD DISTRIBUTION SYSTEM
TOTAL TRIHALOMETHANES (a)

1989-1993

(mg/L)

Location Code	Sample Point	1991 First Quarter 27-Feb	1991 Second Quarter 15-May	1991 Third Quarter 14-Aug	1991 Fourth Quarter 13-Nov	1992 First Quarter 26-Feb	1992 Second Quarter 24-Jun	1992 Third Quarter 23-Sep	1992 Fourth Quarter 28-Oct
UMS-3	Bay Bridge Pumps	0.068	0.144	0.131	0.064	0.077	0.092	0.143 (b)	0.097
UMS-5	Laguna & Lombard	0.066	0.147	0.133 (b)	0.066	0.073 (b)	0.086	0.126	0.092 (b)
CHS-1	S.F. General Hospital	0.030	0.142	0.121	0.031 (b)	0.063	0.083	0.133 (b)	0.048
CHS	Shell Station, Bush & Steiner	0.038	0.118	0.097	0.041 (b)	0.067	0.078	0.073	0.063
SS-1	42nd Ave & Geary Blvd.	0.048 (b)	0.134	0.10	0.049	0.071 (b)	0.080 (b)	0.087	0.071
SS	425 Mason Street	0.039	0.141	0.112	0.044 (b)	0.072 (b)	0.066 (b)	0.083 (b)	0.048
SS-7	Fillmore & Turk	0.056	0.131 (b)	0.112	0.047	0.073	0.084	0.072 (b)	0.070
PHS	20th St & Missouri	0.034	0.095 (b)	0.079 (b)	0.036	0.065	0.065	0.057	0.052 (b)
LS	Powell & Jackson (library)	0.050	0.119	0.103	0.047	0.069	0.076	0.058	0.067 (b)
SHO	SHR chlorine Station	0.063	0.141	0.120 (b)	0.053	0.082 (b)	0.069 (b)	0.089 (b)	0.068
SHS-2	SR Chlorine Station	NS (c)	0.144	0.096	0.047	0.089	0.094	0.096	0.071
SHS-3	McAteer High School	0.066 (b)	0.144	0.121	0.056 (b)	0.076	0.092	0.095	0.064
Sutro Out	Olympia & Clarendon	0.056	0.144	0.062	0.060	0.089	0.10	0.105	0.087 (b)
SS	Chevron @ California, bet Taylor & Mason	0.056 (b)	0.148 (b)	0.132 (b)	0.080	0.079	0.081	0.131	0.077 (b)
Sutro Sys-4	Guadalupe School	NS (c)	0.148	0.083	0.046	0.090	0.077	0.130	0.056
McLaren Sys-1	Wilde & Girard	0.077 (b)	0.144	0.177	0.106	0.094 (b)	0.090	0.138	0.069
	Average Quarterly Concentration	**0.0534**	**0.1365**	**0.1112**	**0.0546**	**0.0768**	**0.0821**	**0.1010**	**0.0688**
	Running Average--Most Recent 4 Quarters	**0.0712**	**0.0880**	**0.0987**	**0.0889**	**0.0948**	**0.0812**	**0.0786**	**0.0822**

(Continued)

Source: SFWD report submitted to DHS.

Notes:

(a) EPA and DHS MCL for THMs is 0.10 mg/L. Compliance is based on a running annual average of quarterly samples.
(b) Average of two sample results collected at the same location.
(c) NS: Not sampled.

TABLE 5-19 (Cont'd)

SFWD DISTRIBUTION SYSTEM
TOTAL TRIHALOMETHANES(a)

1989-1993

(mg/L)

Location Code	Sample Point	1993 First Quarter 3-Mar	1993 Second Quarter 14-Apr	1993 Third Quarter 22-Sep	1993 Fourth Quarter 20-Oct
UMS-3	Bay Bridge Pumps	0.085	0.099 (b)	0.088	0.096
UMS-5	Laguna & Lombard	0.083	0.096	0.087	0.098 (b)
CHS-1	S.F. General Hospital	0.086	0.086	0.088	0.094
CHS	Shell Station, Bush & Steiner	0.059	0.087	0.077 (b)	0.080
SS-1	42nd Ave & Geary Blvd.	0.069 (b)	0.061	0.054	0.085
SS	425 Mason Street	0.061 (b)	0.068	0.072	0.078 (b)
SS-7	Fillmore & Turk	0.057	0.078	0.068	0.087
PHS	20th St & Missouri	0.053	0.066	0.051 (b)	0.062
LS	Powell & Jackson (library)	0.058	0.077 (b)	0.065	0.084
SHO	SHR chlorine Station	0.079	0.116	0.073	0.103 (b)
SHS-2	SR Chlorine Station	0.094	0.109	0.104	0.062
SHS-3	McAteer High School	0.089 (b)	0.111	0.099 (b)	0.097
Sutro Out	Olympia & Clarendon	0.085	0.111	0.060	0.058
SS	Chevron @ California, bet Taylor & Mason	0.087	0.114	0.068	0.102
Sutro Sys-4	Guadalupe School	0.054	0.091	0.060	0.060 (b)
McLaren Sys-1	Wilde & Girard	0.086	0.107 (b)	0.082 (b)	0.083
	Average Quarterly Concentration	**0.0741**	**0.0923**	**0.0748**	**0.0831**
	Running Average--Most Recent 4 Quarters	**0.0815**	**0.0841**	**0.0775**	**0.0811**

Source: SFWD report submitted to DHS.

Notes:

(a) EPA and DHS MCL for THMs is 0.10 mg/L. Compliance is based on a running annual average of quarterly samples.
(b) Average of two sample results collected at the same location.
(c) NS: Not sampled

DHS determined that all surface waters in California are subject to potential contamination from *Giardia lamblia* and viruses. Tests for both *Giardia lamblia* and *Cryptosporidium* have shown very low levels, although the tests have yielded some positive results in the Calaveras and San Antonio waters. A summary of historical microbiology appears under the section *Description of Existing Water Quality* and is presented in Table 5-11.

In accordance with the SWTR, DHS requires 99.9 percent (3 log) reduction of *Giardia* cysts and a 99.99 percent (4 log) reduction of viruses, to be achieved through filtration and disinfection. Use of approved treatment technologies satisfies the SWTR requirements in lieu of confirmatory sampling data. Surface water supplies meeting the following filtration and disinfection requirements shall be deemed to be in compliance. The Sunol WTP is effective at meeting all current regulations pertaining to the SWTR. More specific information on filtration and disinfection is provided below.

Filtration

The rules promulgated by DHS state that filtration treatment must meet performance and operating criteria to comply with the pathogen removals specified above. The performance criteria are as follows.

- Turbidity of the filtered water shall be less than or equal to 0.5 NTU in 95 percent of the measurements taken each month.

- Turbidity shall not exceed 5.0 NTU at any time.

- For grab sample monitoring, the filtered water shall not exceed 1.0 NTU in more than two samples taken in consecutive four-hour intervals while the plant is in operation.

Table 5-17 presents turbidity data from treated water. With the exception of January 1993, each month between 99.3 percent and 100 percent of the treated water samples had turbidity levels less than 0.5 NTU, complying with the 95 percent requirement. Turbidity did not exceed 5.0 NTU during this time period. Finally, the filtered water did not exceed 1.0 NTU in more than two consecutive samples.

In addition to performance criteria, filtration plants must meet operating criteria to comply with the pathogen removal and inactivation requirements of the SWTR. The operating criteria stipulate the following.

- Conventional and direct filtration dual media filters shall not exceed flow rates of 6.0 gpm/sf.
- The effluent from each filter shall be monitored for turbidity, continuously or with a grab sampling program approved by DHS.
- After an interruption event (e.g. backwashing, repairs, etc.) the performance of each individual filter unit shall not exceed the following:
  1) 2.0 NTU;
  2) 1.0 NTU in at least 90 percent of the interruption events during any consecutive 12-month period:
  3) 0.5 NTU after the filter has been in operation for more than 4 hours.
- Coagulation and flocculation unit shall demonstrate an 80 percent reduction of the monthly raw water turbidity through the filters.

Sunol WTP has twelve dual media filters, each with an area of 1,850 sq. ft. At the plant's maximum treatment capacity, if all filters are in service, this is a loading rate of 5 gpm/sf. The Sunol WTP maintains historical data on each individual filter in the historical data trends database. The monthly turbidity removal rates through the filters are shown in Table 5-17. They range from 91.5 percent to 98.2 percent, well above the minimum 80 percent reduction.

Disinfection

In order to satisfy the pathogen removal and inactivation requirements of the SWTR, disinfection treatment must also meet the performance and operating standards.

- Water delivered to the distribution system shall contain a disinfectant residual of not less than 0.2 mg/L for more than four hours in any 24-hour period.
- The disinfection residual concentrations of samples collected from the distribution system shall be detectable in at least 95 percent of the samples taken each month, during each and every two consecutive months that the system serves water to the public. The disinfectant

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

residual must be measured at the same time and at the same locations from which total coliforms are sampled.

The disinfection residual is monitored continuously at the point where treatment plant effluent enters the distribution system. Table 5-20 presents a summary of data on disinfection residuals throughout the distribution system between February 1993 and January 1994. Between 98.8 percent and 100 percent of the samples had a measurable residual, complying with the 95 percent requirement. The TCR states that each month, 95 percent of the total coliform samples collected throughout the distribution system must be negative. Table 5-18 presents the coliform sampling results. From February 1993 to January 1994 between 0 percent and 4 percent of the samples were positive, within the TCR requirement.

The disinfection operating criteria stipulate the following.

- A supply of chemicals shall be maintained as a reserve, or demonstrated to be available.

- In the event of disinfection failure, an emergency plan shall be developed for implementation to prevent the delivery of inadequately disinfected water.

Emergency procedures in the event of a disinfection failure are explained in the procedures manual located on the Operator's desk at the Sunol WTP.

CONCLUSIONS

Calaveras and San Antonio Reservoirs exhibit different water quality characteristics. San Antonio Reservoir water is typically more variable, reflecting the influence of a number of sources of inflow: local runoff, Hetch Hetchy, Calaveras Reservoir, and the State Water Project. San Antonio Reservoir displays seasonal behavior, with stratification in the summer months. However, the bottom depths generally remain aerobic throughout the year. In recent years, San Antonio Reservoir has had increased levels of chlorides, conductivity, and sodium. This is due to water transfers from the State Water Project into the reservoir.

Calaveras receives only local runoff as inflow. It is highly stratified during the warm weather months. An aeration system was recently installed to alleviate anoxic conditions in the hypolimnion and reduce levels of dissolved iron, manganese, and hydrogen sulfide.

TABLE 5-20

SFWD DISTRIBUTION SYSTEM DISINFECTION RESIDUAL (a, b)

February 1993 to January 1994

	No. of Samples	Samples Without Residual	Percent With Residual
1993			
February	302	0	100.0%
March	339	0	100.0%
April	311	0	100.0%
May	324	0	100.0%
June	329	4	98.8%
July	314	0	100.0%
August	327	3	99.1%
September	328	2	99.4%
October	296	0	100.0%
November	302	0	100.0%
December	300	0	100.0%
1994			
January	311	0	100.0%

(a) Source: SFWD report submitted to DHS.

(b) Disinfection residual must be measureable or HPC<500/ml in 95% of the distribution system samples.

The raw waters in the Alameda reservoirs have elevated turbidity levels, and the Sunol WTP is very effective at removing particulates so that the turbidity of the treated water meets current drinking water standards. In particular, the Sunol WTP treated water quality and operations meet all the current regulations pertaining to the SWTR.

SECTION 6

ANALYSIS OF PENINSULA WATERSHED WATER QUALITY CONDITIONS

Section Six describes the water quality in the Peninsula Watershed System. Relevant drinking water regulations in the U.S. are summarized at the beginning of Section Five. The various monitoring programs which were used for this evaluation are profiled at the beginning of this section, followed by a description of the physical control facilities. This information provides an overview of reservoir operations and the operating criteria that guide water management decisions. Historical water quality data is compiled and reviewed, and depth profiles display the seasonal limnological behavior of each reservoir. Analytical data are evaluated using time series and descriptive statistics to determine the "typical" water qualities of the Peninsula reservoirs, as well as the fluctuations which occur. Raw and treated water qualities are compared with drinking water standards, and the ability of the Peninsula watershed system to meet the SWTR is assessed. This evaluation technique indicates which water quality parameters require treatment and the adequacy of current treatment to achieve the current drinking water regulations. Finally, the water quality recommendations are in Section Ten.

SUMMARY OF AVAILABLE WATER QUALITY DATA

Through concurrent monitoring programs, the SFWD has monitored water quality in the Peninsula watershed and related public water supply system for over fifty years. SFWD tests water quality in reservoirs, along transmission pipelines, at influent points to water treatment plants, treated water, and throughout the distribution network. This section describes the primary monitoring programs used to provide the evaluated data. Table 6-1 summarizes the SFWD monitoring efforts and Figure 6-1 shows the sampling locations within the watershed.

The Water Quality Division of the SFWD provided the data on the Peninsula watershed. The 1990 WQPS database was the source of much of the information compiled in this section, updated where SFWD supplied additional data. The elements of each of the monitoring programs are briefly described below:

- **Conventional Water Quality –** SFWD staff sample San Andreas Reservoir for conventional water quality parameters on an approximate weekly basis. San Andreas Reservoir was identified as being representative of the Peninsula watershed system since Peninsula watershed water is conveyed to San Andreas for storage prior to treatment and delivery.

TABLE 6-1

PENINSULA WATERSHED
LONG-TERM MONITORING PROGRAMS (a, b)

1940 to 1993

	Conventional WQ	Annual Monitoring	Limnology
Sample Collection	G	G	G
Frequency	W	A, SA	V
Program Term	1940-1993	1978-1993	1983-1993
Parameters			
Physical Characteristics			
Alkalinity	•	•	•
Bicarbonate		•	
Carbonate		•	
Color		•	
Conductivity	•	•	•
Hardness	•	•	•
pH	•	•	•
Temperature	•		•
Total MBAS		•	
Total Dissolved Solids (TDS)		•	
Turbidity	•	•	•
Inorganics			
Boron		•	
Chloride		•	•
Fluoride		•	
Nitrogen (Ammonia)		•	•
Nitrogen (Nitrate)		•	•
Nitrogen (Nitrite)		•	
Oxygen (Dissolved)		•	•
Phosphorus		•	•
Silica		•	
Sulfate		•	
Radionuclides			
Gross Alpha		(c)	
Gross Beta		(c)	
Strontium-90		(c)	
Tritium		(c)	

(Continued)

TABLE 6-1 (Con't)

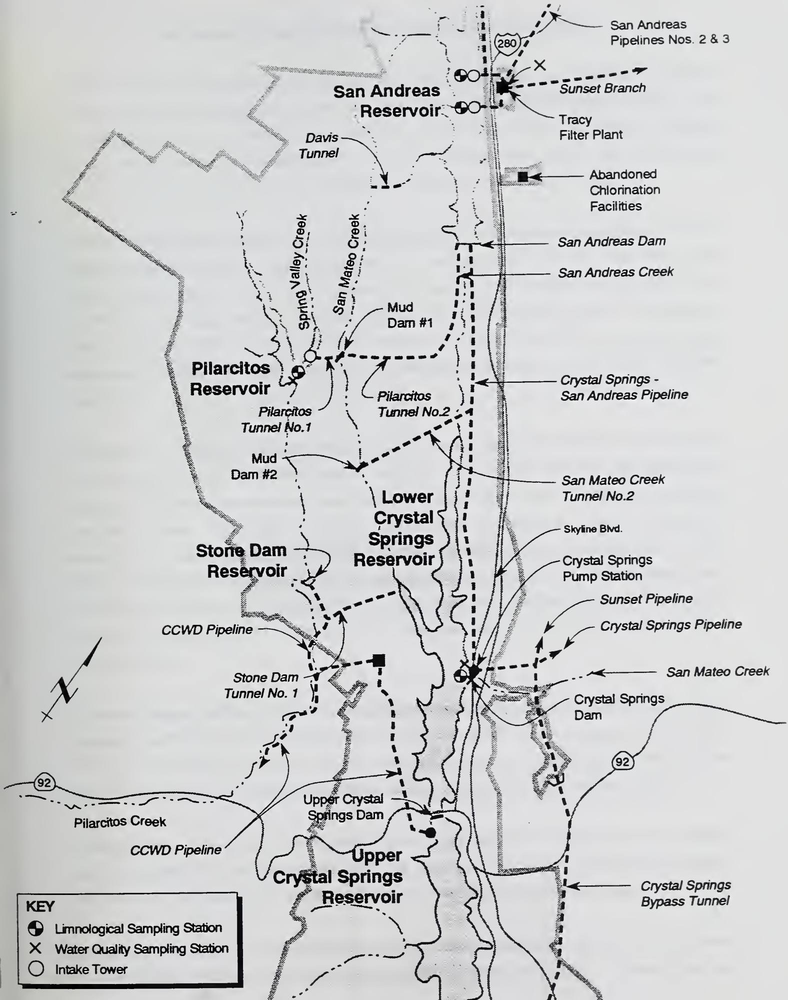
PENINSULA WATERSHED
LONG-TERM MONITORING PROGRAMS (a, b)

1940 to 1993

	Conventional WQ	Annual Monitoring	Limnology
Sample Collection	G	G	G
Frequency	W	A, SA	V
Program Term	1940-1993	1978-1993	1983-1993
Parameters			
Metals			
Aluminum		•	
Arsenic		•	
Barium		•	
Cadmium		•	
Calcium		•	
Chromium		•	
Copper		•	
Iron		•	
Lead		•	
Magnesium		•	
Manganese		•	
Mercury		•	
Potassium		•	
Selenium		•	
Silver		•	
Sodium		•	
Zinc		•	
Organics			
Endrin		(c)	
Lindane		(c)	
Methoxyclor		(c)	
Toxaphene		(c)	
2, 4-D		(c)	
2, 4, 5-TP Silvex		(c)	
Total Organic Carbon (TOC)			•
Microbiology			
Coliform	•		
Plankton			•
Other			
Asbestos		(c)	

(a) Source: SFWD
(b) This table does not include special studies.
(c) Supplemental component ofannual monitoring program.

G: Grab
W: Weekly
A: Annual
SA: Semi-Annual
V: Varies



PENINSULA WATERSHED SAMPLING STATIONS

Schematic Only-Not To Scale
Source: SFWD 1993 & Systech Engineering, Inc.
637.0070.EDAW.6/95

FIGURE 6-1

MONTGOMERY WATSON

Staff records pH and temperature in situ, and collects samples for alkalinity, coliform, hardness, specific conductance, and turbidity which are analyzed subsequently at the Millbrae laboratory. As stated in Section Five, one element of the WQPS was a database incorporating twenty years of historical water quality information, 1969 to 1989. Discussion of this data can be found in the *Evaluation of Data* section, later in this chapter.

- **Annual Monitoring Reports –** SFWD conducts annual or semi-annual sampling at Crystal Springs, Pilarcitos, and San Andreas Reservoirs, as well as at the Harry W. Tracy WTP. The data from this monitoring program originated in annual reports submitted to DHS from 1978 to 1992. Parameters include: general physical and mineral characteristics, inorganics, metals, organics, THMs, asbestos, and radioactivity. In addition, SFWD has recently began monitoring chlorine residuals between the Balancing Reservoir and Crystal Springs Reservoir.

- **Limnology –** SFWD staff sample water quality at various depths to establish vertical profiles of reservoir behavior. The limnological assessment evaluates the following parameters: alkalinity, chloride, conductivity, dissolved oxygen, hardness, iron, manganese, ammonia nitrogen, nitrate, nitrite, orthophosphate, pH, sulfate, temperature, TOC, and turbidity. Monthly data can be plotted to construct isopleths, or lines of equal concentration, to show seasonal limnological conditions. Data was compiled and plotted for Crystal Springs and San Andreas Reservoirs. Data for Pilarcitos Reservoir was limited; water quality profiles were not conducted in 1987, 1992, and 1993, and there were only two profiles performed in 1986 and 1991.

- **Algae & Copper Sulfate Application –** SFWD records indicate that copper sulfate was used for algal control in the Peninsula reservoirs as early as 1912. For the purposes of this report, however, only information from 1943 to 1993 was entered into the database, including the date, the identification of the problem algae, and the amount of copper sulfate applied.

- **Precipitation –** A rain gage measures precipitation at each reservoir, and the data is given to the Department of Water Resources (DWR) as part of a cooperative program. The monthly precipitation data included in this chapter was retrieved from the DWR database.

Stemming from the SDWA of 1986, SFWD has conducted a number of special studies in recent years, among them organics, metals, asbestos, inorganics, pathogens, THMs, radionuclides, and

D/DBPs. Table 6-1 lists only on-going monitoring programs. Tables 5-4 and 5-5 list current SFWD monitoring waivers as well as those under consideration by DHS.

PHYSICAL CONTROL FACILITIES

Section Two of this report provides an overview of the San Francisco water supply, conveyance, and treatment system. Included in the following section are descriptions of operating criteria, intake protection features, and treatment practices.

Reservoir Operating Criteria

The Raker Act, described in Section Two, requires maximum use of local water resources. The following criteria were developed by SFWD to guide reservoir operations in the Peninsula system in compliance with this Act.

- Drawdown the reservoir levels by December 1st so that there is available storage within each reservoir to accommodate an average annual runoff.
- By April 1st, maximize the amount of water stored in Peninsula reservoirs. If there is inadequate precipitation to meet the April storage target, then augment the water supplies from Hetch Hetchy and Alameda systems when possible.
- Maximize water in storage at San Andreas Reservoir.
- Maintain adequate storage in Pilarcitos Reservoir to meet water deliveries to Coastside County Water District.
- SFWD has designated Pilarcitos Reservoir an emergency supply, and retains 500 mgal in storage in the event of an emergency.
- Restrict the amount of water allowed to spill from Crystal Springs Reservoir to comply with hydraulic limitations.

In late autumn, the SFWD lowers the level in each reservoir by the amount shown in Table 6-2, so that there is a total of 5,000 mgal of available storage in the Peninsula system by early December. This is accomplished by increasing use of local reservoir supplies, and/or decreasing

deliveries to the Peninsula from Hetch Hetchy and Alameda sources. Reservoirs are kept at or below intermediate goal levels from December to April to avoid spilling winter runoff, thereby maximizing use of local water supplies in accordance with the Raker Act.

TABLE 6-2

PENINSULA WATERSHED RESERVOIR OPERATION

Reservoir	Average Annual Watershed Production (mgal)	April Storage Target (mgal)	December Storage Target (mgal)
Crystal Springs	2,900	19,000	16,100
Pilarcitos	1,100	1,000	500
San Andreas	1,000	6,200	4,600
Total	**5,000**	**26,200**	**21,200**

Source: SFWD, 1994

Water is conveyed from Crystal Springs and Pilarcitos Reservoirs to San Andreas Reservoir. Water storage in San Andreas is maximized to the extent possible so that it is available for withdrawal, treatment, and delivery. All water from the Peninsula reservoirs is treated at the Harry W. Tracy WTP prior to use. Water must be pumped from San Andreas Reservoir to the filter plant.

Table 6-3 illustrates the production of the Peninsula reservoirs. Based on these flows, the hydraulic residence time of San Andreas Reservoir is 0.3 year, Crystal Springs Reservoir is approximately 1 year, and the hydraulic residence time of Pilarcitos Reservoir is approximately 2 years.

Intake Protection Features

A wet intake tower (also called outflow structure) typically has a number of ports at various depths, as shown in Figure 5-2 in the previous section. This allows operational flexibility so that the highest quality water can be withdrawn from the reservoir, given a range of water levels and limnological scenarios. As stated in Section Five, during anoxic conditions water is withdrawn from the port at which phytoplankton communities and dissolved metals are minimized, so as to optimize the quality of the water.

TABLE 6-3

PENINSULA WATERSHED PRODUCTION(a)

Year(b)	1994	1993	1992	1991	1990
Crystal Springs Reservoir					
mgal	-268	5,827	972	-1,488	-1,164
ac-ft	-87	1,898	317	-485	-379
Pilarcitos Reservoir					
mgal	159	260	148	181	184
ac-ft	52	85	48	59	60
San Andreas Reservoir					
mgal	-2,658	2,084	1,355	1,031	1,728
ac-ft	-866	679	441	336	563
Peninsula Watershed Subtotal					
mgal	-2,766	8,170	2,476	-276	748
ac-ft	-901	2,661	807	-90	244

Source: SFWD, 1994

Notes:

(a) Production indicates change in storage on a monthly basis, summed over fiscal year.

(b) Based on SFWD fiscal year, July 1 through June 30.

There are two intake ports in Lower Crystal Springs Reservoir, each with ports at three different levels from which water can be withdrawn. Pilarcitos Reservoir has both a spillway and an intake tower. The spillway releases water to Stone Dam, for subsequent delivery to Coastside County Water District or transfer to Crystal Springs Reservoir. The Pilarcitos intake tower has a single port. San Andreas Reservoir has two intake structures--with one and two ports.

Treatment

Prior to entering the distribution system, all water from the Peninsula reservoirs is treated at the Harry W. Tracy WTP (Tracy WTP), described below. According to staff, from 1950 to 1983, alum was applied to preimpoundment reservoirs to control turbidity. Blue-green algae were eliminated and phosphate concentrations declined. In 1983, alum pretreatment was discontinued when all water was routed through the Tracy WTP for treatment. Staff also indicated that Pilarcitos Reservoir and Stone Dam had aeration systems installed in the 1970s. In 1986, the systems were abandoned due to pump maintenance issues.

Copper Sulfate Application. The only treatment currently performed by SFWD within the Peninsula reservoirs is algal control using copper sulfate. When a reservoir experiences a bloom, SFWD staff identify the algae and estimate the copper sulfate dosage required, using a grid calibrated for volume at various water surface elevations. Upper and Lower Crystal Springs Reservoirs were treated with copper sulfate to control algae as early as 1912. In reviewing more recent SFWD files, there is a single record of copper sulfate applied to Upper Crystal Springs in 1987. Records of copper sulfate applications in Pilarcitos Reservoir date from 1930 to 1943; no later data was encountered. Copper sulfate has been applied to San Andreas Reservoir more regularly, roughly twice a year. Figure 6-2 summarizes the copper sulfate records in San Andreas Reservoir for the period 1943 to 1993. The graph documents SFWD's success in their efforts to reduce the amount of copper sulfate used, decreasing nearly an order of magnitude since the mid-1960s. The other reservoir with a long copper sulfate time series, San Antonio Reservoir in Figure 5-4, also showed a significant decrease. Because of the sensitivity of aquatic organisms to copper and the resultant discharge limits on wastewater effluents, SFWD has been optimizing copper sulfate use. This topic is discussed in more detail in Section Five.

Harry W. Tracy Filter Plant. The San Andreas WTP was rededicated on February 25, 1994 in recognition of Harry W. Tracy, and is now called the Harry W. Tracy WTP. This plant started operation in 1972 and was recently modified to increase its capacity from 80 mgd to 180 mgd.

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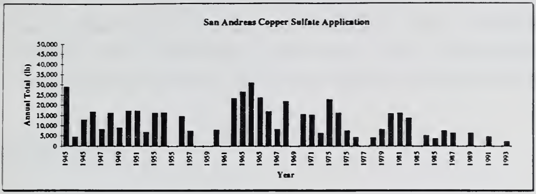
Figure 6-2

SAN ANDREAS COPPER SULFATE APPLICATION

1943-1993



Monthly Copper Sulfate Application

(lb)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual Total
1943				6,500		8,000		7,650				6,980	29,130
1944					4,700								4,700
1945				5,200	7,700								12,900
1946				8,200		8,600							16,800
1947								8,400					8,400
1948				8,800							7,500		16,300
1949									9,000				9,000
1950					8,700			8,600					17,300
1951			8,700								8,700		17,400
1952									7,000				7,000
1953			8,700									7,600	16,300
1954									8,450			8,050	16,500
1955													0
1956				6,400						8,300			14,700
1957												7,450	7,450
1958													0
1959													0
1960			7,900										7,900
1961													0
1962		8,000							8,000			7,500	23,500
1963				9,300			9,500			7,900			26,700
1964	7,600	8,050			8,450			7,000					31,100
1965			8,050			8,240		7,440					23,730
1966	8,880				8,240								17,120
1967						8,400							8,400
1968			8,000			7,680				6,240			21,920
1969													0
1970			8,200			7,440							15,640
1971			8,320									7,000	15,320
1972					6,400								6,400
1973		6,800			8,300			7,800					22,900
1974		8,500							7,800				16,300
1975	7,700												7,700
1976												4,400	4,400
1977													0
1978					1,800							2,500	4,300
1979				8,400									8,400
1980		5,600			6,000							4,500	16,100
1981		2,200		2,100						12,100			16,400
1982					8,500							5,300	13,800
1983													0
1984							5,200						5,200
1985				3,700									3,700
1986				4,400		3,200							7,600
1987									6,550				6,550
1988													0
1989			6,550										6,550
1990													0
1991				4,750									4,750
1992													0
1993			2,400										2,400

Source: SFWD, 1994

The existing plant was designed as a conventional water treatment plant, but is operated as a direct filtration plant. Sodium hypochlorite and ozone are used to disinfect the water and sodium hydroxide is used to adjust the pH. Hydrofluosilicic acid is also added at the WTP to provide fluoride in this treated water. This facility is used to supply upper elevation customers from Millbrae to the College Hill and Sunset Reservoirs in the City through the San Andreas Pipelines.

EVALUATION OF DATA

This section reviews water quality data provided by the SFWD for the WSS. Limnological profiles show the seasonal behavior of each reservoir. For water quality parameters of concern, time series graphs display historical concentrations and descriptive statistics profile each parameter. Finally, this section discusses potential long-range changes in water quality.

Description of Existing Water Quality

This section summarizes historical water quality data collected as part of the on-going SFWD monitoring programs. Limnology profiles document seasonal behavior in Peninsula reservoirs.

The Peninsula watershed system yields approximately five percent of the water in the San Francisco system on an average annual basis. There are significant transfers of water from the Hetch Hetchy system and treated water from Alameda reservoirs into Crystal Springs and San Andreas Reservoirs. However, due to the influence of local runoff, Peninsula water quality varies from that of Hetch Hetchy water.

Water from both Pilarcitos and Crystal Springs Reservoirs is transferred to San Andreas Reservoir prior to treatment and delivery. Because San Andreas Reservoir is the common point prior to treatment, for some parameters this reservoir is considered representative of the Peninsula watershed system.

Table 6-4 presents a statistical summary of the water quality parameters measured at San Andreas Reservoir between 1969 and 1989. Tables 6-5, 6-6, and 6-7 tabulate the results of monitoring efforts submitted to DHS in the annual reports, and one table corresponds to Crystal Springs, Pilarcitos, and San Andreas Reservoirs, respectively.

TABLE 6-4

PENINSULA WATERSHED
CONVENTIONAL WATER QUALITY

1969 to 1989

San Andreas Reservoir

Alkalinity	mg/L	Coliform	% positive
Number of Samples	1009	Number of Samples	1031
Mean	44.46	Mean	43.17
Median	42	Median	40
Standard Deviation	10.9	Standard Deviation	23.34
Standard Error	0.34	Standard Error	0.73
Minimum	4.2	Minimum	0
Maximum	130	Maximum	98.4
Lower Quartile	38	Lower Quartile	24
Upper Quartile	50	Upper Quartile	61.5
Hardness	**mg/L**	**pH**	
Number of Samples	1009	Number of Samples	1007
Mean	54.51	Mean	7.86
Median	52	Median	7.9
Standard Deviation	25.24	Standard Deviation	0.27
Standard Error	0.79	Standard Error	0.01
Minimum	12	Minimum	6.8
Maximum	86	Maximum	9.4
Lower Quartile	44	Lower Quartile	7.7
Upper Quartile	60	Upper Quartile	8
Specific Conductance	**µmho/cm**	**Temperature**	**°F**
Number of Samples	1009	Number of Samples	241
Mean	138.09	Mean	58.98
Median	135	Median	59
Standard Deviation	35.62	Standard Deviation	6.88
Standard Error	1.12	Standard Error	0.44
Minimum	9.3	Minimum	44
Maximum	310	Maximum	87
Lower Quartile	110	Lower Quartile	54
Upper Quartile	156	Upper Quartile	64
Turbidity	**NTU**		
Number of Samples	1007		
Mean	2.25		
Median	1		
Standard Deviation	4.08		
Standard Error	0.13		
Minimum	0.1		
Maximum	55		
Lower Quartile	0.65		
Upper Quartile	2		

Source: WQPS (SFWD, 1990)

TABLE 6-5

CRYSTAL SPRINGS RESERVOIR
ANNUAL MONITORING REPORTS (a)

1978 to 1992

Parameters	units	Drinking Water Standards limit	type	Regulatory Authority	4/20/78	6/14/79	6/9/80	4/7/81	10/27/82	7/25/83	1/30/84	9/17/84	10/17/85	11/10/86	9/17/87	9/7/88	9/5/89	9/12/90	9/24/91	9/15/92
Physical Characteristics																				
Alkalinity	mg/L				37.3	27.4	38.0	44	58	70	70.0	59	42	50.3	52.3	27.0	36.8	38	44	50
Bicarbonate	mg/L				45.5	33.3	46.4	54	34	77	76	71.4	51	61	63.8	32.9	44.5	NS		NS
Carbonate	mg/L				0.0	0	0.0	0	0.3	0.8	0	0	0	0.2	0.0	0	0.3	NS		NS
Color	units	15.	SMCL	EPA, DHS	0	0	0	5	10	20	10	0	0	5	10	2	0	10	0	NS
Conductivity	μmho/cm				136	82	121	134	160	230	223	188	119	148	144	75	104	101	135	181
Hardness	mg/L				46.1	32.0	52.0	52	68	88	86.0	72	48	58.0	56.3	28.8	41.8	40	52	58
pH	units	6.5-8.5	SMCL	EPA	7.6	7.5	7.6	7.8	8.0	8.3	8.0	8.0	8	7.9	7.4	7.3	8.1	8.2	8.2	7.8
Total ABS					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.02	NS	NS	NS		NS
Total Dissolved Solids (TDS)	mg/L	500.	SMCL	EPA, DHS	77	52	88	92	111	138	131	97	72	90	79	51.5	62	61	81	109
Turbidity	NTU	0.5 (b)	MCL	EPA, DHS	1.5	0.80	2.5	11	2.4	0.8	2.5	0.8	0.7	0.5	1.9	0.6	1.4	0.6	0.6	0.4
Inorganics																				
Boron	mg/L				0.07	0.04	0.04	0.14	0.14	0.2	0.05	0.24	0.15	0.4	0.3	0.3	0.2	0.1	0.2	
Chloride	mg/L	250.	SMCL	EPA, DHS	11.1	6.5	13.0	9.0	11	15	15.0	11.5	10	9.2	7.8	3.1	7.2	7.0	11	15
Dissolved Oxygen	mg/L				8.7	9.2	9.2	10.1	9.1	8.9	10.7	8.2	8.3	8.6	8.6	8.9	9.2	NS	9.1	8.8
Fluoride	mg/L	1.4-2.4(c)	MCL	EPA	0.09	0.03	0.05	0.08	0.06	0.02	0.09	0.02	0.04	0.05	0.06	0.02	0.04	0.1	0.1	0.1
Hydroxide	mg/L				0.0	0	0.0	0	0	0	0	0	0	0.2	0.0	NS	NS	NS	NS	NS
Nitrate	mg/L	10.	MCL	EPA, DHS	0.2	0	0.25	0.4	0.24	1.6	1.6	1.9	1.9	1.4	<0.5	0.00 (d)	0.3	0.1	<0.4	<0.4
Nitrite	mg/L	1.	MCL	EPA	<0.003	<0.003	<0.001	0.003	0.001	0.006	<0.001	0.003	<0.001	0.002	<0.003	<0.01	0.007	<0.01	<0.3	<0.3
Phosphorus	mg/L				<0.01	<0.01	0.03	0.05	0.12	<0.05	0.04	<0.05	0.04	<0.01	<0.001	0.004	0.002	<0.01	<0.01	NS
Silica	mg/L				6	3.7	7.4	3.3	7.6	9.0	7.1	4.0	3.6	3.8	3.0	NS	2.2	3.0	3.1	NS
Sulfate	mg/L	250.	SMCL	EPA, DHS	9.4	5.5	8.2	10.4	12.5	18.5	17.6	13.3	7.2	7.1	9.0	3.6	5.6	5.1	9	9.3
Metals																				
Aluminum	mg/L	1. (e)	MCL	DHS	0.05	<0.02	0.03	<0.10	<0.10	0.07	0.02	0.03	0.02	0.01	0.06	0.02	0.017	0.05	0.1	0.035
Arsenic	mg/L	0.05	MCL	EPA, DHS	<0.01	<0.005	<0.01	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.001	<0.005	<0.001
Barium	mg/L	1. (f)	MCL	DHS	<0.25	<0.25	<0.50	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.05	0.02	0.02	0.02	0.017
Cadmium	mg/L	0.005	MCL	EPA	<0.002	<0.002	<0.002	<0.002	0.000(d)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001
Calcium	mg/L				11.6	10.4	12.0	15.2	16.6	16.5	20.8	17.4	15	14.7	15.1	8.2	11.4	10	13	14
Chromium	mg/L	0.05 (g)	MCL	DHS	<0.005	<0.01	<0.01	<0.01	0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.002	<0.005	<0.001
Copper	mg/L	1.3 (h)	MCL	EPA	0.01	<0.02	0.05	<0.01	0.003	0.023	0.004	<0.001	0.002	0.001	0.005	0.002	<0.001	0.003	0.007	0.007
Iron	mg/L	0.3	SMCL	EPA, DHS	0.09	<0.08	0.08	0.08	0.081	0.062	.10	0.04	0.06	0.031	0.089	0.022	0.025	0.04	0.07	0.028
Lead	mg/L	0.015 (h)	MCL	EPA	<0.02	<0.02	<0.02	<0.02	0.000(d)	<0.001	<0.001	<0.001	<0.002	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.005	0.001
Magnesium	mg/L				4.1	1.5	5.3	3.4	6.4	8.4	8.3	7.0	2.6	5.1	4.5	2.0	3.3	4.0	5	5.6
Manganese	mg/L	0.05	SMCL	EPA, DHS	<0.005	<0.01	<0.02	<0.02	0.012	0.002	0.008	0.008	0.003	0.021	0.043	4.4	0.004	0.006	0.009	0.006
Mercury	mg/L	0.002	MCL	EPA, DHS	<0.0005	<0.0005	<0.0005	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.001	<0.0005	<0.001	<0.002	<0.001	<0.001	<0.0002	<0.0002
Potassium	mg/L				0.8	0.7	0.86	0.9	1.2	1.2	1.4	0.9	0.6	0.7	0.6	0.7	0.6	0.6	0.8	1.2
Selenium	mg/L	0.01 (i)	MCL	DHS	<0.0025	<0.002	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.001	<0.005	<0.002
Silver	mg/L	0.05 (j)	MCL	DHS	<0.005	<0.003	<0.01	<0.01	0.000(d)	<0.001	<0.001	<0.001	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NS
Sodium	mg/L	20. (k)	SMCL	EPA	6.3	1.9	6.5	8.7	7.0	11.2	9.2	8.5	5.5	5.9	6.1	2.6	4.3	5.0	8.1	11.5
Zinc	mg/L	5.	SMCL	EPA, DHS	0.01	<0.01	<0.02	<0.02	0.000(d)	0.001	0.008	<0.001	0.002	<0.001	0.005	0.001	<0.001	0.001	0.006	0.006

Notes:
(a) Annual sampling at Lower Crystal Springs, as listed in SFWD water quality reports submitted to DHS
(b) Action level based on 95% of samples.
(c) DHS limit: 1.4-2.4 mg/l MCL, depending on temperature. EPA limits: 4 mg/l MCL; 2 mg/l SMCL. Applies to naturally occuring fluoride.
(d) No detection limit reported
(e) EPA limit: 0.05-0.2 mg/l SMCL
(f) EPA limit: 2 mg/l MCL.
(g) EPA limit: 0.1 mg/l MCL.
(h) Action level based on 90% of samples
(i) EPA limit: 0.05 mg/l MCL.
(j) EPA limit: 0.1 mg/l SMCL.
(k) Not really a secondary standard, but recommended for people on severely restricted diets
NS Not sampled

TABLE 6-6

PILARCITOS RESERVOIR
ANNUAL MONITORING REPORTs (a)

1978 to 1992

Parameters	units	Drinking Water Standards limit	type	Regulatory Authority	Sampling Date 4/20/78	6/15/79	6/10/80	4/7/81	10/21/82	7/25/83	1/30/84	9/17/84	10/22/85	11/13/86	9/17/87	9/7/88	9/5/89	9/12/90	9/24/91	9/15/92
Physical Characteristics																				
Alkalinity	mg/L				53.1	59.2	53.0	62	52	50	48.0	58	60	59.6	59.2	62.8	60.2	66	62	61
Bicarbonate	mg/L				64.8	71.6	64.7	76	29	55	51	68.0	73	72.3	72.2	75.5	73	NS		
Carbonate	mg/L				0.0	0	0.0	0	0	0	0	1.0	0	0.1	0.0	0	0.1	NS		
Color	units	15.	SMCL	EPA, DHS	17	5	5	0	10	15	10	5	5	25	10	5	0	15	5	NS
Conductivity	μmho/cm				204	187	161	178	159	161	169	192	194	181	194	207	200	210	210	226
Hardness	mg/L				60.6	65.2	64.0	62	56	50	50.5	60	72	61.6	60.9	66.2	65.8	71	72	68
pH	units	6.5-8.5	SMCL	EPA	8.1	7.9	8.2	8.0	8.0	8.0	7.6	8.5	7.8	7.7	7.7	8.2	7.5	8.3	8.2	7.9
Total ABS					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.02	NS		NS	NS	NS
Total Dissolved Solids (TDS)	mg/L	500.	SMCL	EPA, DHS	117	120	111	121	103	101	116	116	122	109	113	119	120	126	126	136
Turbidity	NTU	0.5 (b)	MCL	EPA, DHS	3.4	0.70	0.56	0.90	1.0	0.5	3.0	0.4	0.7	1.2	0.8	0.4	0.8	1.2	0.3	1.0
Inorganics																				
Boron	mg/L				0.04	0.05	0.01	0.06	0.08	0.05	0.02	0.11	0.06	<0.2	0.3	0.5	0.2	<0.1	0.07	NS
Chloride	mg/L	250.	SMCL	EPA, DHS	24.2	21.8	23.0	21	18	17	18.0	18.4	21	18.1	19.6	15.9	21.6	23	24	24
Dissolved Oxygen	mg/L				9.9	9.7	9.7	10.4	9.7	8.9	10.3	8.9	8.1	8.5	8.5	8.7	9.2	NS	9	9.1
Fluoride	mg/L	1.4-2.4(c)	MCL	EPA	0.02	0.1	0.11	0.02	0.10	0.03	0.13	0.10	0.12	0.1	0.11	0.13	0.12	0.1	0.1	0.1
Hydroxide	mg/L				0.0	0	0.0	0	0	0	0	0	0	<0.2	0.0	NS	NS	NS		NS
Nitrate	mg/L	10.	MCL	EPA, DHS	<0.1	0.2	0.23	<0.1	0.28	1.5	1.8	1.8	1.8	1.6	<0.5	0.03	0.3	0.1	<0.4	<0.4
Nitrite	mg/L	1.	MCL	EPA	<0.003	<0.003	<0.001	0.003	0.003	<0.002	0.003	0.002	<0.001	0.007	<0.003	<0.01	0.004	<0.01	<0.3	<0.3
Phosphate	mg/L				<0.01	<0.01	0.03	0.05	0.23	<0.05	0.11	<0.05	0.04	<0.01	0.004	0.00	0.002	0.04	<0.01	NS
Silica	mg/L				12.9	6.5	10.5	11.0	15.5	14.5	15.2	11.8	13	11.8	6.6	NS	9.2	7.0	6.5	NS
Sulfate	mg/L	250.	SMCL	EPA, DHS	8.0	7.5	8.0	8.1	6.5	7.1	7.6	7.9	8	2.4	7.4	9.9	7.6	7.5	7.7	7.1
Metals																				
Aluminum	mg/L	1. (d)	MCL	DHS	0.06	<0.05	0.01	<0.10	<0.10	0.03	0.02	<0.01	0.2	0.01	0.06	0.06	0.002	0.08	0.036	0.021
Arsenic	mg/L	0.05	MCL	EPA, DHS	<0.01	<0.005	<0.01	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.001	<0.005	<0.001
Barium	mg/L	1. (e)	MCL	DHS	<0.25	<0.25	<0.50	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.05	0.03	0.02	0.02	0.015
Cadmium	mg/L	0.005	MCL	EPA	<0.002	<0.002	<0.002	<0.002	0.000(f)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001
Calcium	mg/L				17.1	18.8	15.2	16.0	11.4	10.6	16.7	16.3	19	15.9	17.2	17.9	17.6	18	18	18
Chromium	mg/L	0.05 (g)	MCL	DHS	<0.005	<0.01	<0.01	<0.01	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.005	<0.001
Copper	mg/L	1.3 (h)	MCL	EPA	0.04	<0.03	0.02	<0.01	0.002	0.003	0.001	0.001	<0.002	0.001	0.016	0.002	<0.001	0.002	0.006	0.002
Iron	mg/L	0.3	SMCL	EPA, DHS	0.18	<0.08	0.06	0.05	0.084	0.040	0.18	0.04	0.04	0.042	0.060	0.026	0.325	0.15	0.02	0.037
Lead	mg/L	0.015 (h)	MCL	EPA	<0.02	<0.02	<0.02	<0.02	0.000(f)	<0.001	<0.001	<0.001	<0.002	<0.0005	0.003	<0.001	<0.001	<0.001	<0.005	0.002
Magnesium	mg/L				4.4	4.4	6.3	5.4	4.3	3.6	2.2	4.8	6	5.3	4.3	5.2	5.3	6.0	6	5.3
Manganese	mg/L	0.05	SMCL	EPA, DHS	<0.005	<0.01	<0.02	<0.02	0.017	0.002	0.015	0.008	0.096	0.064	0.104	9.7	0.011	0.020	0.007	0.015
Mercury	mg/L	0.002	MCL	EPA, DHS	<0.0005	<0.0005	<0.0005	<0.0005	<0.0002	<0.0005	<0.0005	<0.0005	<0.001	<0.0005	<0.001	<0.002	<0.001	<0.001	<0.0002	<0.0002
Potassium	mg/L				0.6	0.6	0.76	0.7	0.6	0.4	0.7	0.4	0.3	0.4	0.4	0.5	0.6	0.6	0.6	0.5
Selenium	mg/L	0.01 (i)	MCL	DHS	<0.0025	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.001	<0.005	<0.002
Silver	mg/L	.05 (j)	MCL	DHS	<0.005	<0.003	<0.01	<0.01	0.000(f)	<0.001	<0.001	<0.001	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NS
Sodium	mg/L	20. (k)	SMCL	EPA	13.9	14.9	13.1	17.7	11.3	13.2	10.9	13.9	8.2	12.6	14.4	14.0	14.9	16.4	17	16.7
Zinc	mg/L	5.	SMCL	EPA, DHS	0.003	<0.05	<0.02	<0.02	0.000(f)	0.001	<0.001	0.005	<0.001	<0.001	0.028	0.002	0.001	0.001	0.004	0.004

Notes:

(a) Annual sampling as listed in SFWD water quality reports submitted to DHS
(b) Action level based on 95% of samples.
(c) DHS limit: 1.4 2 mg/L MCL, depending on temperature. EPA limits. 4 mg/L MCL; 2 mg/L SMCL. Applies to naturally occurring fluoride
(d) EPA limit: 0.05-0.2 mg/l SMCL.
(e) EPA limit: 2 mg/l MCL.
(f) No detection limit reported.
(g) EPA limit: 0.1 mg/l MCL.
(h) Action level based on 90% of samples.
(i) EPA limit: 0.05 mg/l MCL.
(j) EPA limit: 0.1 mg/l SMCL.
(k) Not really a secondary standard, but recommended for people on severely restricted diets
NS Not sampled

SAN ANDREAS RESERVOIR
ANNUAL MONITORING REPORT(a)

1982 to 1992

Parameters	units	Drinking Water Standards limit	type	Regulatory Authority	Sampling Date 10/27/82	7/25/83	1/30/84	9/17/84	10/17/85	11/10/86	9/17/87	9/7/88	9/5/89	9/12/90	9/24/91	9/15/92
Physical Characteristics																
Alkalinity	mg/L				58	66	58.5	65	49	55.5	55.6	33.9	41.6	41	44	47
Bicarbonate	mg/L				34	71	60	78.0	60	66.7	67.8	41.2	51	NS	NS	NS
Carbonate	mg/L				0	0	0	0.8	0	0.5	0	0	0.1	NS	NS	NS
Color	units	15.	SMCL	EPA, DHS	10	15	30	0	0	10	7	0	0	10	0	NS
Conductivity	µmho/cm				160	209	222	208	144	162	157	97	115	114	130	176
Hardness	mg/L				68	76	80.0	80	60	62.7	60.3	37.0	46.2	44	52	56
pH	units	6.5-8.5	SMCL	EPA	7.9	8.2	7.2	8.3	7.9	8.2	7.5	7.7	7.7	8.0	8.3	7.7
Total ABS					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.02	NS	NS	NS	NS	NS
Total Dissolved Solids (TDS)	mg/L	500.	SMCL	EPA, DHS	115	125	133	114	83	95	82	55.5	69	68	78	106
Turbidity	NTU	0.5 (b)	MCL	EPA, DHS	0.9	1.7	5.7	0.6	0.74	2.0	0.9	0.6	1.1	0.9	0.4	6.8
Inorganics																
Boron	mg/L				0.12	0.15	0.05	0.22	0.06	0.3	<0.1	0.2	0.2	0.1	0.1	NS
Chloride	mg/L	250.	SMCL	EPA, DHS	12	15	17.0	13.4	11	10.4	9.0	5.5	8.1	8.0	10	15
Dissolved Oxygen	mg/L				9.0	9.2	11.0	8.6	8.5	9.5	8.4	8.8	9.2	NS	NS	9.0
Fluoride	mg/L	1.4-2.4(c)	MCL	EPA	0.10	0.02	0.15	0.08	0.09	0.08	0.09	0.1	0.07	0.1	NS	0.1
Hydroxide	mg/L				0	0	0	0	0	<0.2	0.0	NS	NS	NS	NS	NS
Nitrate	mg/L	10.	MCL	EPA, DHS	0.24	1.5	1.7	1.8	1.5	1.9	<0.5	0.1	0.3	0.1	<0.4	<0.4
Nitrite	mg/L	1.	MCL	EPA	0.005	0.009	0.001	0.004	<0.001	0.003	<0.003	<0.01	0.007	<0.01	<0.3	<0.3
Phosphate	mg/L				0.08	<0.05	0.16	<0.05	0.04	<0.01	<0.001	0.00 (d)	0.01	<0.01	<0.01	NS
Silica	mg/L				6.8	7.5	6.1	3.3	2.8	3.4	1.0	NS	2.6	2.6	2.8	NS
Sulfate	mg/L	250.	SMCL	EPA, DHS	13.0	12.0	25.0	12.7	8.7	7.4	9.8	3.6	6.0	5.6	6.9	9.2
Metals																
Aluminum	mg/L	1. (e)	MCL	DHS	<0.10	0.05	0.04	0.03	0.3	0.07	0.14	0.04	0.037	0.10	0.036	0.053
Arsenic	mg/L	0.05	MCL	EPA, DHS	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.001	<0.005	<0.001
Barium	mg/L	1. (f)	MCL	DHS	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.05	0.03	0.02	0.02	0.047
Cadmium	mg/L	0.005	MCL	EPA	0.000(d)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0001
Calcium	mg/L				15.1	15.0	19.9	19.0	16	16.0	16.6	10.1	12.0	11	13	14
Chromium	mg/L	0.05 (g)	MCL	DHS	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.003	<0.005	0.004
Copper	mg/L	1.3 (h)	MCL	EPA	0.011	0.013	&0.01(l)	0.002	0.002	0.002	0.07	0.015	<0.001	0.004	<0.005	0.017
Iron	mg/L	0.3	SMCL	EPA, DHS	0.065	0.149	&0.03(l)	0.03	0.06	0.111	0.06	0.035	0.028	0.06	0.02	0.17
Lead	mg/L	0.015 (h)	MCL	EPA	0.000(d)	<0.001	<0.001	<0.001	<0.002	<0.0005	0.002	<0.001	<0.001	<0.001	<0.005	0.003
Magnesium	mg/L				6.8	7.3	7.4	7.9	4.9	5.5	4.6	2.9	3.9	4.0	4.9	4.9
Manganese	mg/L	0.05	SMCL	EPA, DHS	0.01	0.004	0.019	0.005	0.008	0.017	0.038	2.3	0.01	0.01	0.006	0.014
Mercury	mg/L	0.002	MCL	EPA, DHS	<.0002	<0.0005	<0.0005	<0.0005	<0.001	<0.0005	<0.001	<0.002	<0.001	<0.001	<0.0002	<0.0002
Potassium	mg/L				1.1	1.0	1.3	0.9	0.7	0.7	0.7	0.5	0.6	0.7	<0.1	1.2
Selenium	mg/L	0.01 (i)	MCL	DHS	<0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	<0.01	<0.005	<0.001	<0.005	<0.002
Silver	mg/L	0.05 (j)	MCL	DHS	0.000(d)	<0.001	<0.001	<0.001	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NS
Sodium	mg/L	20. (k)	SMCL	EPA	7.6	11.5	9.5	8.9	6.8	7.0	7.0	3.7	5.1	5.4	7	11.2
Zinc	mg/L	5.	SMCL	EPA, DHS	0.000(d)	<0.001	0.006	0.002	0.001	0.024	0.003	0.003	0.004	0.004	<0.001	0.056

Notes:
(a) Annual sampling as listed in SFWD water quality reports submitted to DHS.
(b) Action level based on 95% of samples.
(c) DHS limit: 1.4-2.4 mg/l MCL, depending on temperature. EPA limits: 4 mg/l MCL; 2 mg/l SMCL. Applies to naturally occuring fluoride.
(d) No detection limit reported.
(e) EPA limit: 0.05-0.2 mg/l SMCL.
(f) EPA limit: 2 mg/l MCL.
(g) EPA limit: 0.1 mg/l MCL.
(h) Action level based on 90% of samples.
(i) EPA limit: 0.05 mg/l MCL.
(j) EPA limit: 0.1 mg/l SMCL.
(k) Not a secondary standard; recommended for people on severely restricted diets
NS Not sampled.

Physical Characteristics. At Crystal Springs and Pilarcitos Reservoirs, turbidity was measured in conjunction with the annual sampling. Crystal Springs ranged between 0.4 and 2.5 NTU, while Pilarcitos fluctuated from 0.3 to 3.4 NTU. Between 1969 and 1989, over 1,000 turbidity measurements were taken at San Andreas Reservoir. Ninety-five percent of the raw water turbidity measurements collected at San Andreas Reservoir were 6.5 NTU or below. The average turbidity for this same time period was 2.25 NTU with a standard deviation of 4.1 NTU. Raw water turbidity exhibited both seasonal and diurnal patterns. The turbidity increased in winter months in response to precipitation and runoff, and remained low through the summer and early fall. WTP operators report that afternoon winds during the spring and summer result in turbulence in the water column and elevate turbidity levels to between 5 and 10 NTU from 3 to 10 p.m. In 1982, a 100-year storm event occurred, and turbidity levels exceeded 20 NTU for five months.

SFWD staff took over 200 temperature measurements in San Andreas Reservoir. Temperature fluctuated on a seasonal basis, although no thermal stratification was evident. The *Limnology* section discusses temperature and related qualities in more detail.

Mineral Quality. Annual pH measurements at Crystal Springs and Pilarcitos Reservoirs yielded values between 7.3 and 8.3 at Crystal Springs, and 7.5 to 8.5 at Pilarcitos. pH was measured in San Andreas over 1,000 times; the average pH in San Andreas Reservoir was 7.9 with a standard deviation of 0.27, and 90 percent of the pH readings were less than 8.65. pH varied seasonally, with average monthly values slightly higher between May and September.

Alkalinity at Crystal Springs ranged between 27 and 70 mg/L, and Pilarcitos varied from 48 to 71 mg/L. The SFWD sampled alkalinity at San Andreas more than 1,000 times, with a mean concentration of 44.5 mg/L, and a standard deviation of 10.9 mg/L. Ninety percent of the alkalinity values were below 58 mg/L. At Crystal Springs Reservoir, hardness varied from 28.8 to 88 mg/L. Pilarcitos yielded much more consistent concentrations, ranging between 50 and 72 mg/L. San Andreas Reservoir averaged hardness values of 54.5 mg/L with a standard deviation of 25.2 mg/L. Ninety percent of the samples were below 70 mg/L.

Crystal Springs Reservoir had specific conductance measurements between 75 and 230 µmho/cm, while Pilarcitos water exhibited little variation, ranging between 159 and 226 µmho/cm. The San Andreas monitoring program accrued more than 1,000 measurements, averaging a specific conductance of 138 µmho/cm, and a standard deviation of 35.6 µmho/cm. Ninety percent of the San Andreas readings were below 190 µmho/cm.

Metals. Tables 6-5, 6-6, and 6-7 list the metal concentrations of raw waters in Crystal Springs, Pilarcitos, and San Andreas Reservoirs. Metals concentrations found in raw waters are below drinking water standards, with the following two exceptions. In 1988, every manganese sample for all reservoirs had results two to three orders of magnitude higher than typical levels, and is likely to indicate an erroneous reading. Sampling of raw water at Pilarcitos Reservoir has yielded manganese levels ranging between 0.064 and 0.104 mg/L, above the SMCL of 0.05 mg/L for drinking water. Also, there was a single instance where iron was measured at 0.325 mg/L in a raw water sample, higher than the SMCL of 0.3 mg/L for drinking water. All water from Pilarcitos must be treated at the Tracy WTP before entering Peninsula or San Francisco distribution systems. However, metals concentrations are not routinely measured after treatment. Water from Pilarcitos Reservoir may also be transferred to Coastside County Water District, where it is treated prior to use.

SFWD has begun annual sampling for the following Phase V metals as required in the regulations: antimony, beryllium, nickel, and thallium.

Microbiology. SFWD uses the presence-absence test to sample for coliform. Coliform levels in San Andreas Reservoir exhibit seasonal patterns, with the presence of coliforms peaking in December and January, thus coinciding with wet weather and surface runoff. Between April and September, the presence of coliforms is consistently low on an average monthly basis (WQPS: SFWD, 1990).

In December, 1989, the SFWD conducted a sampling program for *Giardia* and *Cryptosporidium* at both Upper and Lower Crystal Springs, as well as San Andreas Reservoirs. *Giardia* was not detected in any of the samples. Upper and Lower Crystal Springs samples were negative for *Cryptosporidium. Cryptosporidium* was detected at a concentration of 0.03 oocysts/100L at San Andreas (WQPS: SFWD 1990).

In 1993, SFWD conducted bi-weekly testing for *Giardia* and *Cryptosporidium,* as shown in Table 6-8. San Andreas Reservoir was selected for the sampling because all water is transferred into this reservoir prior to treatment and distribution. *Giardia* was present in two samples at 0.3 and 0.5 cysts/100L, and *Cryptosporidium* was detected in six samples, ranging from 0.5 to 2.1 oocysts/100L. This sampling program will continue through 1994. The section entitled *Evaluation of the System's Ability to Meet the SWTR* further discusses pathogens and the risks to drinking water.

TABLE 6-8

PENINSULA WATERSHED PATHOGEN STUDIES

January 1993 to January 1994
San Andreas Reservoir

Date	turbidity (a) (NTU)	total coliform (MPN)	fecal coliform (MPN)	Giardia lamblia (cysts/ 100 L)	Cryptosporidium (oocysts/ 100 L)
1/5/93	2.7	<2	<2	0.3	2.1
1/20/93	8.7	220	23	<0.3	<0.3
2/2/93	7.7	NS	NS	<0.3	<0.3
2/16/93	29.0	3,500	120	<0.3	<0.3
3/2/93	4.3	4	<2	<0.3	<0.3
3/16/93	2.3	5	<2	<0.3	<0.3
3/30/93	2.3	320	2	<0.3	<0.3
4/12/93	2.2	13	<2	<0.3	<0.3
4/28/93	3.7	72	5	<0.3	<0.3
5/11/93	7.3	11	2	<0.3	<0.3
5/25/93	2.0	<2	<2	<0.3	<0.3
6/8/93	1.8	7	7	<0.3	<0.3
6/22/93	0.6	2	2	<0.2	<0.2
7/6/93	1.5	<2	<2	<0.2	0.5
7/20/93	1.3	8	5	<0.9	1.7
8/2/93	0.7	2	<2	<0.2	<0.2
8/19/93	0.8	NS	NS	<0.2	<0.2
8/31/93	1.3	<2	<2	<0.3	<0.3
9/13/93	0.8	2	<2	<0.2	0.5
9/27/93	1.0	2	2	<0.2	<0.2
10/12/93	1.2	11	5	<0.3	0.5
10/25/93	0.8	2	<2	<0.3	0.5
11/9/93	1.0	8	<2	<0.3	<0.3
11/23/93	0.8	2	<2	<0.2	<0.2
12/7/93	0.9	NS	NS	<0.3	<0.3
12/21/93	0.4	<2	<2	<0.2	0.5
1/4/94	0.5	2	<2	0.5	<0.2
1/26/94	1.6	2	2	<0.2	<0.2

Source: SFWD, 1994

Notes:

(a) Turbidity, while not a measure of pathogens, was included in this sampling program to determine if any correlation between turbidity and pathogens exist.

NS: Not Sampled

Using procedures described in Section Five, SFWD staff monitor algae in Peninsula reservoirs, conducting both algal counts and species identification. Counts generally range between 20 to 200 cells per mL. Species identified between 1980 and 1993 are presented in Table 6-9.

TABLE 6-9

PENINSULA WATERSHED RECORDED ALGAL POPULATIONS

1980 to 1993

Algal Species	Algal Type	Water Quality/ Treatment Concern
Anabaena	blue-green	taste and odor algae
Aphanizomenon	blue-green	taste and odor algae
Ceratium	blue-green	taste and odor algae
Cyclotella	diatom	filter-clogging algae
Dinobryon	blue-green	taste and odor algae
Fragilaria	diatom	filter-clogging algae
Melosira	diatom?	filter-clogging algae
Staurastrum	blue-green	taste and odor algae
Stephanodiscus	diatom	filter-clogging algae

Source: SFWD, 1994

Organics. SFWD has requested waivers from DHS for Phase II and Phase V SOCs and VOCs. The waivers are discussed in Section Five in more detail. SFWD provided monitoring data on organic compounds collected on October 13, 1993 for preparation of this WSS. These data are provided in Appendix B. On the basis of these data, all Peninsula samples were below detection limits for all parameters with a single exception. Analysis of a Crystal Springs sample measured 0.8 μg/L chloroform (trichloromethane). Consequently, SFWD is conducting quarterly sampling at Crystal Springs for the next year.

Asbestos. Table 6-10 presents the chronology of asbestos sampling results provided by the SFWD. Current drinking water regulations (7 MFL) target only the long fibers (> 10 μm in length) which are associated with health-related concerns. These health-related concerns pertain to the airborne fibers which, from a drinking water perspective, would occur during activities such as showering or the use of a vaporizer.

TABLE 6-10

PENINSULA ASBESTOS CONCENTRATIONS
RAW AND TREATED WATER

1979 to 1993

Location	Sample Date	Concentration (MFL) (a)	MCL (MFL) (b)
Crystal Springs Reservoir			
	14-Jun-79	5	
	9-Jun-80	28	
	17-Sep-84	31.0	
	13-Oct-93	<0.19	
Pilarcitos Reservoir			
	26-Jun-84	<0.3	
	13-Oct-93	<0.19	
San Andreas Reservoir			
	14-Jun-79	4.1	
	17-Sep-84	6.0	
	13-Oct-93	0.38	
Harry W. Tracy Water Treatment Plant			
	14-Jun-79	ND	7
	9-Jun-80	ND	7
	17-Sep-84	0.9	7
	13-Oct-93	<0.19	7

Sources: Annual monitoring report submitted to DHS, 1979, 1980, 1984. Special study, 1993.
ND = constituent not detected; detection limits not provided with data.
(a) Sampling prior to 1993 was for total fibers. 1993 sampling was for long fibers, greater than 10µm in length.
(b) Current regulations pertain to long fibers only--which are the fibers associated with health-based concerns.

In 1979, 1980, and 1984, Crystal Springs had total asbestos fiber levels (short and long fibers) of 5, 28, and 31 MFL, respectively. The concentrations in the Tracy WTP effluent were below detection limits in 1979 and 1980, and 0.9 MFL in 1984, suggesting that the treatment plant effectively removes asbestos fibers.

SFWD monitored asbestos from 1981 to 1987 in Crystal Springs and San Andreas Reservoirs. The study confirmed higher levels of total asbestos fibers (short and long) in Crystal Springs Reservoir than in San Andreas. According to the WQPS, total asbestos concentrations at Crystal Springs ranged from 3 to 48.6 MFL. San Andreas concentrations ranged from below detection limits to 6.0 MFL.

SFWD tested for long fiber asbestos in the Peninsula reservoirs in October 1993. Pilarcitos and Crystal Springs were below the detection limit, <0.19 MFL. The San Andreas Reservoir raw water sample measured 0.38 MFL. The sample from Tracy WTP effluent did not register any asbestos, once again <0.19 MFL.

Radionuclides. With DHS approval, at the end of 1993, SFWD initiated one year of quarterly sampling for radionuclides. Table 6-11 presents historical data as well as more recent monitoring results.

Disinfectant/Disinfection By-Products (D/DBPs). Early D/DBP regulations focused on THMs. SFWD conducts quarterly monitoring throughout the distribution system, and has achieved the MCL of 0.01 mg/L since 1989. See Section Five for further details.

D/DBP monitoring is not conducted, nor required for raw water. D/DBPs are included in Phase VIA drinking water quality parameters. EPA published the proposed rule in July 1994. SFWD plans to begin monitoring for these parameters in October 1994 in their drinking water distribution system.

Limnology

The SFWD has profiled water quality in the Peninsula Watershed reservoirs throughout the year since 1983. At the deepest point in the reservoir, the sampling team collects up to fifteen grab samples in the water column. Table 6-12 indicates the number of profiles conducted each year by the SFWD for Crystal Springs, Pilarcitos, and San Andreas Reservoirs.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

TABLE 6-11

PENINSULA RADIONUCLIDE CONCENTRATIONS
RAW AND TREATED WATER (a)

(pCi/L)

Location	Date	Gross Alpha		Gross Beta		Radium 226		Radium 228		Radon 222		Strontium 90		Tritium		Uranium
		Sample	Counting Error	Sample	Counting Error	Sample	Counting Error	Sample	Counting Error	Sample	Counting Error	Sample	Counting Error	Sample	Counting Error	Sample
Crystal Springs Reservoir																
	14-Jun-79	<2		<3		NS		NS		NS		<1		<1000		NS
	16-Nov-93	3	2	2	1	NS		NS		0	20	0	1	0	260	0.2
																0.1
Pilarcitos Reservoir																
	16-Nov-93	0	2	2	1	NS		NS		0	20	0	1	0	250	<0.03
San Andreas Reservoir																
	16-Nov-93	1	2	1	1	NS		NS		0	21	0	1	0	250	0.1
																0.1
Harry W. Tracy Water Treatment Plant																
	14-Jun-79	<2		<2		NS		NS		NS		<1		<1,000		NS
	16-Nov-93	0	2	2	1	NS		NS		0	21	0	1	0	250	0.1
																0.1

Notes:
Sources: Annual report submitted to DHS, 1979.
Special study, 1993
NS: Not Sampled

CRYSTAL SPRINGS RESERVOIR[a, b]

Parameter*	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Alkalinity	7	10	10	2	1	21	21	10	8	2	2
Ammonia	0	0	0	0	0	20	21	6	5	0	0
Chloride	7	10	10	2	1	21	21	10	8	2	2
Conductivity	13	10	10	3	1	21	21	10	8	2	3
D.O.	14	10	10	3	1	19	21	10	8	2	3
Hardness	7	10	10	2	1	21	21	10	8	2	2
Iron	0	0	0	0	0	0	0	0	0	0	0
Manganese	0	0	0	0	0	0	0	0	0	0	0
Nitrate	1	10	0	0	0	16	21	6	4	0	0
Nitrite	0	0	0	0	0	0	0	0	1	0	0
O-Phosphorous	1	7	0	0	0	19	21	9	8	2	2
pH	15	10	10	3	1	21	21	10	8	2	3
Sulfate	0	0	0	0	0	0	0	5	3	0	0
TOC	0	0	1	0	0	17	14	6	7	1	2
Temperature	15	10	10	3	1	19	21	10	8	2	3
Turbidity	15	10	10	3	1	21	21	10	8	2	2

[a]Each profile reflects grab sampling at up to 12 depths
[b]Sampling occured in Lower Crystal Springs Reservoir

PILARCITOS RESERVOIR[c]

Parameter*	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Alkalinity	1	6	6	2	0	6	13	6	2	0	0
Ammonia	0	0	0	0	0	5	12	3	2	0	0
Chloride	1	6	6	2	0	6	13	6	2	0	0
Conductivity	5	6	6	3	0	6	13	6	2	0	0
D.O.	5	6	5	3	0	6	13	6	2	0	0
Hardness	1	6	6	2	0	6	13	6	2	0	0
Iron	0	0	0	0	0	0	0	0	0	0	0
Manganese	0	0	0	0	0	0	0	0	0	0	0
Nitrate	0	6	2	0	0	5	13	4	2	0	0
Nitrite	0	0	0	0	0	0	0	0	2	0	0
O-Phosphorous	0	5	0	0	0	6	13	5	2	0	0
pH	5	6	6	3	0	6	13	6	2	0	0
Sulfate	0	0	0	0	0	0	0	4	2	0	0
TOC	0	0	1	0	0	5	9	5	1	0	0
Temperature	5	6	6	3	0	6	13	6	2	0	0
Turbidity	5	6	6	3	0	6	13	6	2	0	0

[c]Each profile reflects grab sampling at up to 10 depths

SAN ANDREAS RESERVOIR[d]

Parameter*	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Alkalinity	7	14	10	4	1	16	18	12	10	11	5
Ammonia	0	0	0	0	0	15	17	9	7	5	3
Chloride	7	14	10	4	1	16	18	12	10	11	5
Conductivity	13	15	10	5	1	16	18	12	10	11	6
D.O.	14	14	9	5	1	16	17	12	10	11	6
Hardness	7	14	10	4	1	16	18	12	10	11	5
Iron	0	0	0	0	0	0	0	0	0	0	0
Manganese	0	0	0	0	0	0	0	0	0	0	0
Nitrate	0	11	2	0	1	11	18	8	6	0	0
Nitrite	0	0	0	0	0	0	0	0	4	0	0
O-Phosphorous	0	8	0	0	1	15	18	8	10	11	6
pH	14	15	10	5	1	16	18	12	10	11	6
Sulfate	0	11	1	0	0	0	0	8	6	0	0
TOC	0	0	1	0	0	13	9	11	7	9	5
Temperature	14	15	10	5	1	16	17	12	10	11	6
Turbidity	14	15	10	5	1	16	18	12	10	11	5

[d]Each profile reflects grab sampling at up to 10 depths

NUMBER OF RESERVOIR WATER QUALITY PROFILES SAMPLED PENINSULA WATERSHED SYSTEM 1983 - 1993

TABLE 6-12

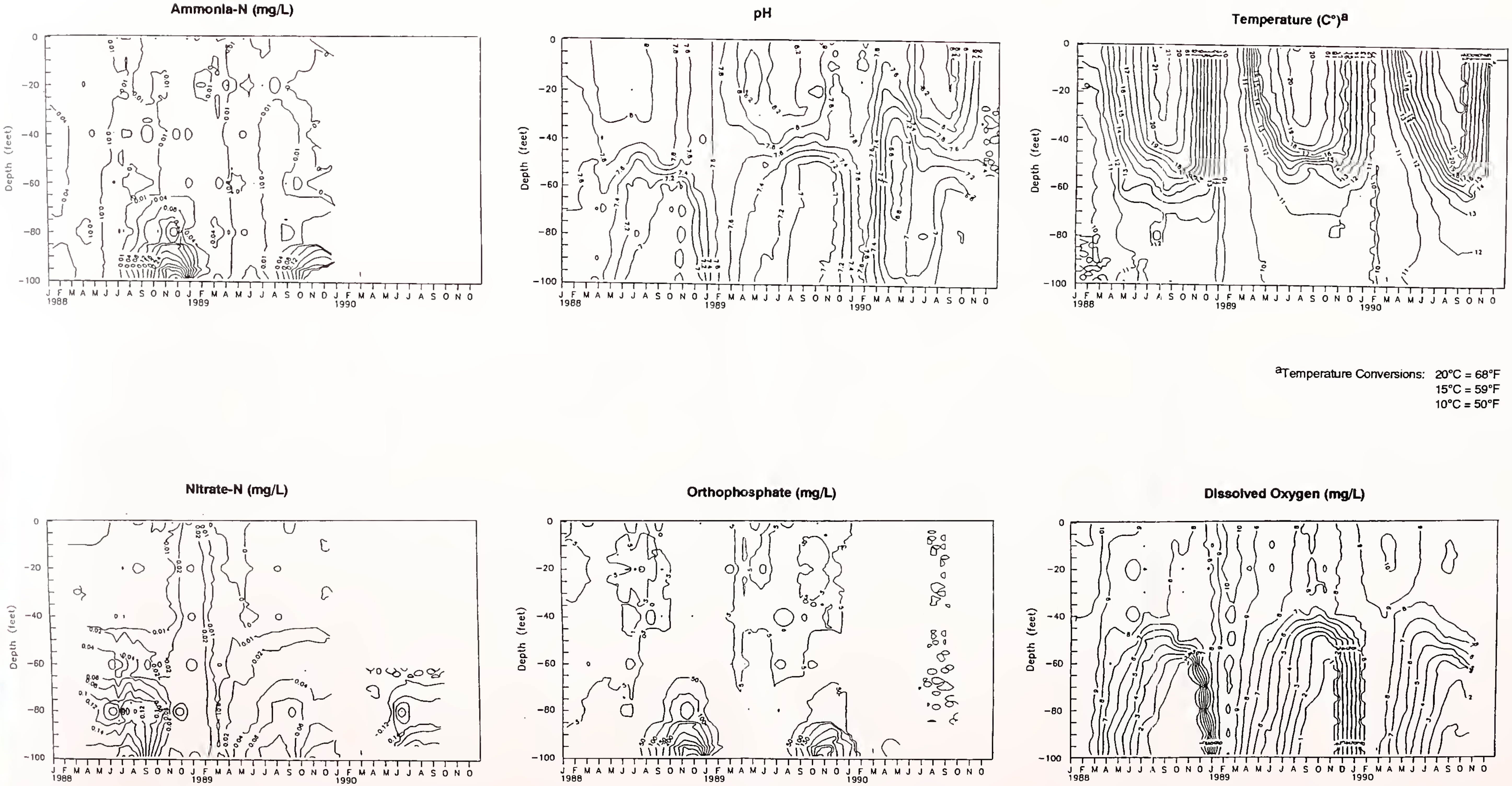
Source: SFWD Lab Data Sheets, 1993.

When graphing vertical profiles of limnological characteristics, reliability and precision increases with the number of data points. January 1988 to December 1990 form the basis of the analysis because of the relatively high numbers of profiles conducted during this time span, see Table 6-12. Drought conditions during these years are likely to have intensified the seasonal patterns and stratification. Figures 6-3 through 6-5 depict stratification, overturn, algal growth, nutrient uptake and dissolved oxygen depletion. Other parameters for which the results showed less clear or consistent patterns are included in Appendix B: alkalinity, conductivity, chlorides, hardness, iron, manganese, nitrites, sulfate, TOC, and turbidity.

The water column was profiled in Lower Crystal Springs Reservoir. The temperature graph, Figure 6-3, clearly displays thermal stratification on a seasonal basis. In January and February the reservoir is vertically mixed, maintaining a constant temperature of 10 to 12°C throughout the profile. Stratification begins in April and is fully developed by late July, with a thermocline 40 to 60 feet below the surface. The epilimnion ranges between 20 and 22°C, while the hypolimnion remains a constant 10 to 12°C throughout the year. Dissolved oxygen conforms to the seasonal thermal stratification pattern, as expected. Dissolved oxygen concentrations range between 8 and 10 mg/L in the epilimnion, while the hypolimnion becomes anoxic toward the end of summer – between August and November.

The data for Pilarcitos Reservoir is limited, yet the available information gives evidence of thermal stratification, see Figure 6-4. For the two wet weather seasons analyzed, the water column is vertically mixed from late December through February. In April stratification begins, and is fully developed by July or August. The thermocline is rather diffused, ranging between 30 and 50 feet deep. The epilimnion reaches 20°C, while the hypolimnion ranges from 9 to 11°C. Figure 6-4 presents the isopleths for dissolved oxygen in Pilarcitos Reservoir. The hypolimnion of the reservoir becomes anoxic from July to December. The isopleths show the depletion of ammonia and nitrate in the epilimnion during the summer, favoring the growth of nitrogen-fixing blue-green algae.

From January 1988 to December 1990, San Andreas Reservoir experienced little stratification. San Andreas Reservoir is relatively shallow. Prevailing winds during the summer months are thought to be the primary mechanism which instigates vertical mixing through the water column, as evidenced by the diurnal fluctuation in turbidities (WQPS, 1990). The profiles indicate a uniform temperature from the surface to the bottom of the water column. The temperature reflects seasonal changes, gradually climbing from a low of 9 to 13°C from December through



[a]Temperature Conversions: 20°C = 68°F
15°C = 59°F
10°C = 50°F

Source: SFWD Lab Data Sheets, 1993.

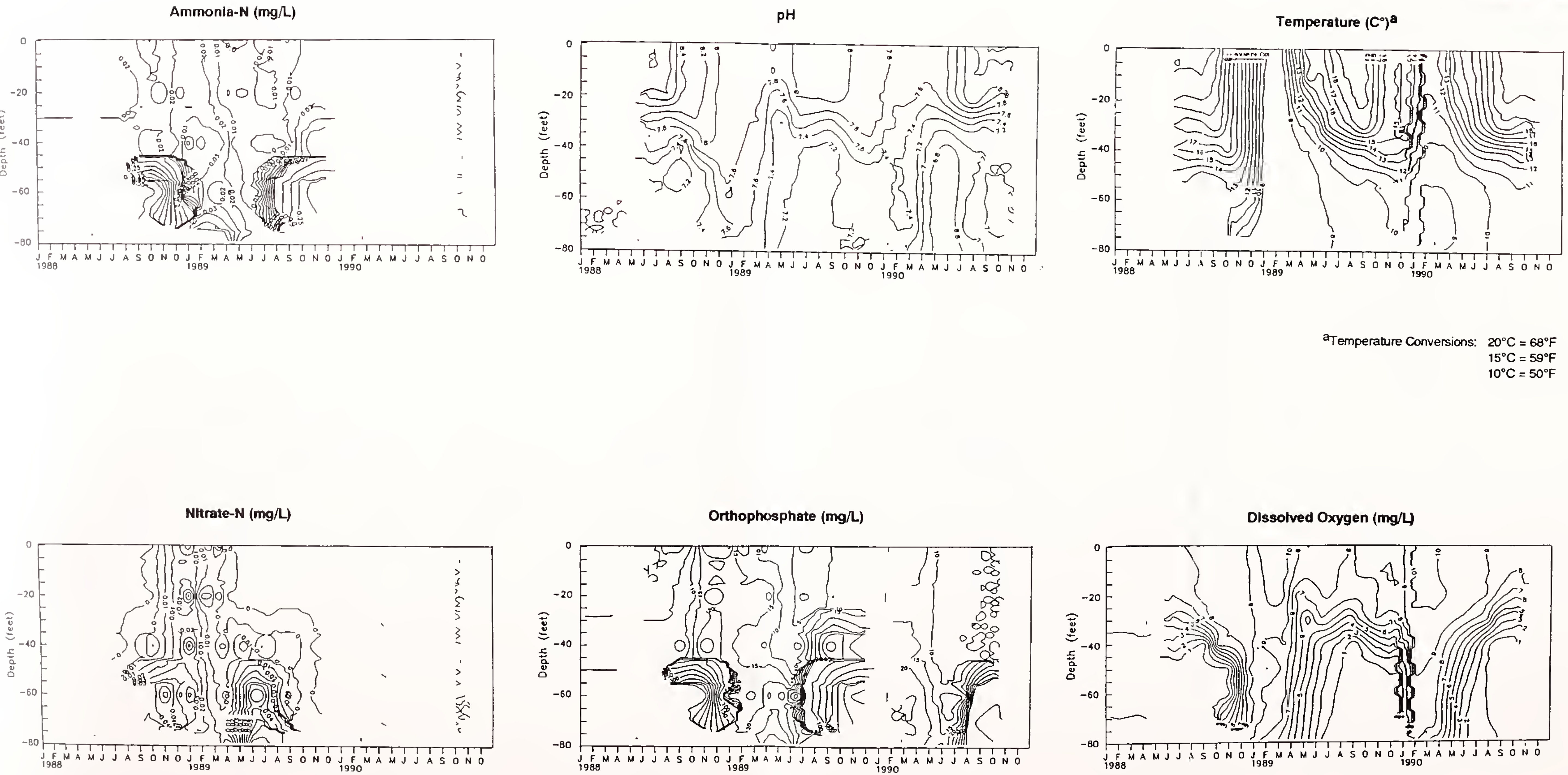
837.0070 CRJ 2/94

MONTGOMERY WATSON

CRYSTAL SPRINGS RESERVOIR LIMNOLOGY[b]
DEPTH PROFILES & ISOPLETHS
1988 - 1990

FIGURE 6-3

[b]Depth sampling in Lower Crystal Springs Reservoir.



Source: SFWD Lab Data Sheets, 1993.

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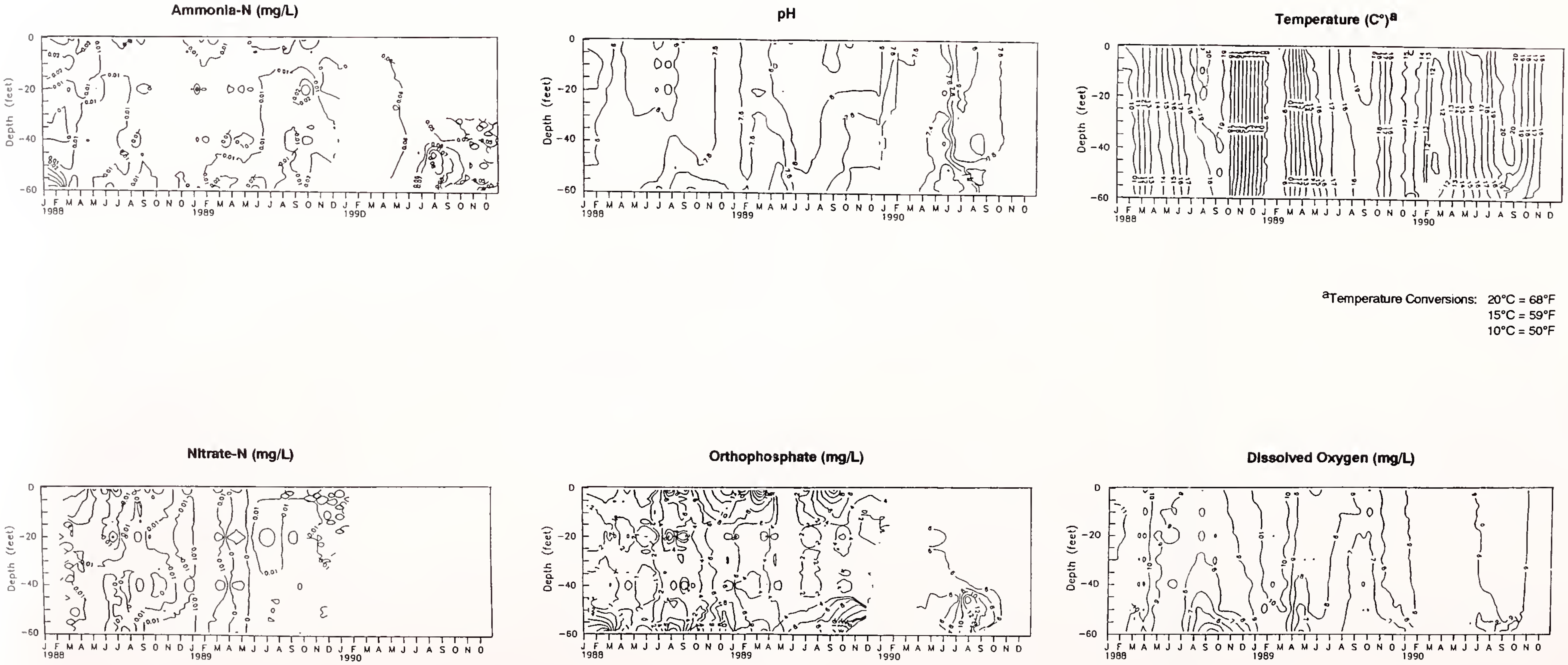
MONTGOMERY WATSON

PILARCITOS RESERVOIR LIMNOLOGY
DEPTH PROFILES & ISOPLETHS
1988 - 1990

FIGURE 6-4



[a]Temperature Conversions: 20°C = 68°F
15°C = 59°F
10°C = 50°F

Source: SFWD Lab Data Sheets, 1993.

637.0070 CRJ 2/94

MONTGOMERY WATSON

SAN ANDREAS RESERVOIR LIMNOLOGY DEPTH PROFILES & ISOPLETHS 1988 - 1990

FIGURE 6-5

March. Maximum surface temperatures were recorded in August at 20°C, after which the reservoir temperature gradually decreased.

Figure 6-5 presents the isopleth curve of dissolved oxygen for San Andreas Reservoir. Because the reservoir is vertically mixed, there is no change in dissolved oxygen concentrations with depth. Rather, the dissolved oxygen levels of San Andreas Reservoir are a function of temperature. In winter months, the dissolved oxygen concentration is 8 to 10 mg/L. In the warmer summer months, the dissolved oxygen concentration is slightly lower, between 7 and 8 mg/L. Figure 6-5 also presents the isopleths of ammonia, nitrate, and phosphate. In the summer, rapid algal growth on the surface appears to deplete ammonia and nitrate concentrations to zero. Phosphorus concentration is decreased to 8 μg/L. This leads to a condition that favors the growth of nitrogen-fixing blue-green algae.

Trends in Water Quality Data

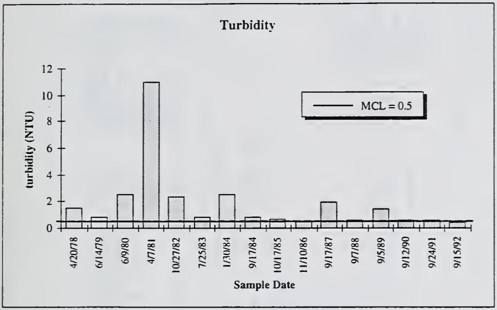
This section reviews historical data for long-term trends which may indicate degradation of water quality. A discussion follows concerning the correlation between precipitation and turbidity levels in the Peninsula water supplies.

Time Series Analysis. Graphical statistical analyses are shown in Figures 6-6, 6-7, and 6-8. For each raw water quality parameter of concern, a time series plot is displayed, as well as a summary of descriptive statistics. Please note that MCLs and SMCLs are shown for comparison purposes only, since drinking water standards do not apply to raw water before treatment.

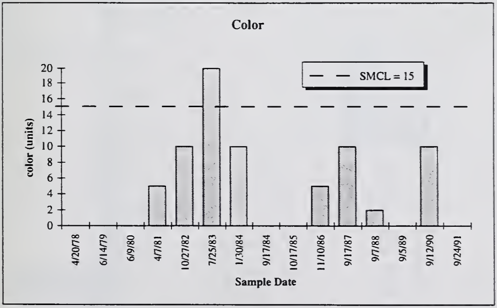
In Crystal Springs Reservoir, the available historical raw water data indicate treatment is required for turbidity and asbestos, and is desirable for color in order to achieve the drinking water standards. As discussed in more detail in *Comparison of Raw/Treated Water to Standards* and *Evaluation of System's Ability To Meet SWTR,* the performance data provided by SFWD indicates that Tracy WTP consistently and reliably removes particulates from raw water, producing a treated water with turbidity levels below regulatory limits. The treatment plant also is effective at removing asbestos, although there is only a single data point. Color in raw waters of Crystal Springs is higher than the SMCL, but this is a secondary standard, concerned with the aesthetic qualities of drinking water. Color is not routinely measured in treated water.

All water from Pilarcitos Reservoir is treated at the Tracy WTP prior to distribution; hence, the preceding discussion applies. Pilarcitos Reservoir has elevated raw water turbidity levels. If

FIGURE 6-6
RAW WATER QUALITY-
CRYSTAL SPRINGS RESERVOIR (a)
TIME SERIES AND STATISTICAL SUMMARIES



Turbidity	
Mean	1.8
Standard Deviation	2.6
Range	10.6
Minimum	.4
Maximum	11.0
Number	16.0



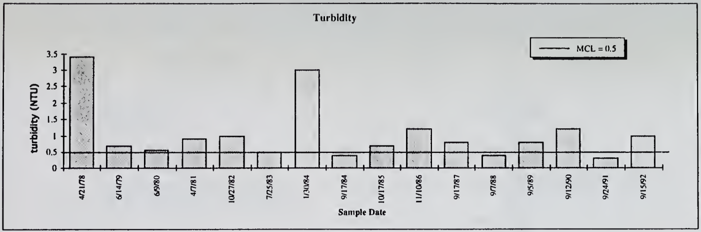
Color	
Mean	4.8
Standard Deviation	6.0
Range	20.0
Minimum	.0
Maximum	20.0
Number	15.0

Sources: SFWD annual reports submitted to DHS.
Special studies, 1993.

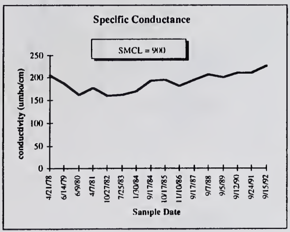
Note: (a) MCLs and SMCLs apply to treated water,NOT raw water, and are shown in this figure only for relative comparison with raw water quality.

FIGURE 6-7
RAW WATER QUALITY-
PILARCITOS RESERVOIR (a)

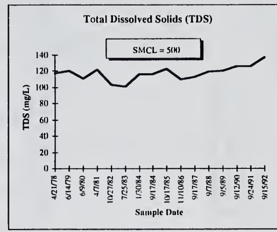
TIME SERIES AND STATISTICAL SUMMARIES



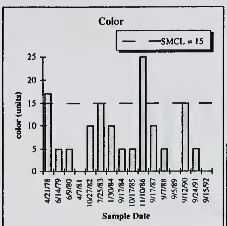
Turbidity	
Mean	1
Std Deviation	1
Range	3
Minimum	0
Maximum	3
Count	#



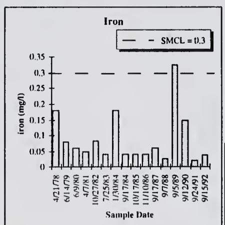
Conductivity	
Mean	186
Std Deviation	18
Range	51
Minimum	159
Maximum	210
Number	14



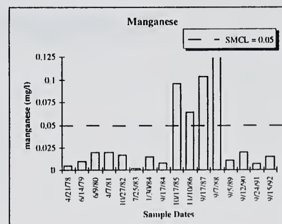
TDS	
Mean	115
Std Deviation	7.2
Range	25
Minimum	101
Maximum	126
Number	14



Color	
Mean	8.8
Std Deviation	6.8
Range	25
Minimum	0
Maximum	25
Number	15



Iron	
Mean	0.1
Std Deviation	0.1
Range	0.3
Minimum	0
Maximum	0.3
Number	16



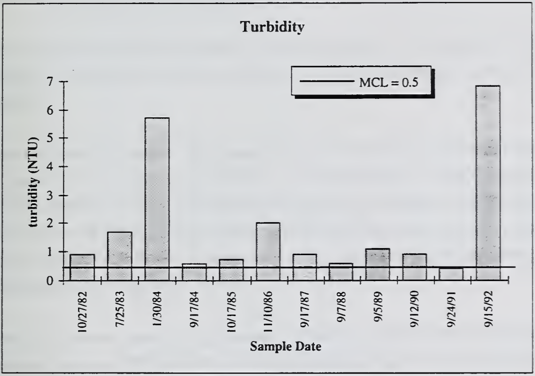
Manganese	
Mean	0 6
Std Deviation	2 4
Range	9 7
Minimum	0
Maximum	9 7
Number	16

Note: (a) MCLs and SMCLs apply to treated water, NOT raw water, and are shown in this figure only for relative comparison with raw water quality.

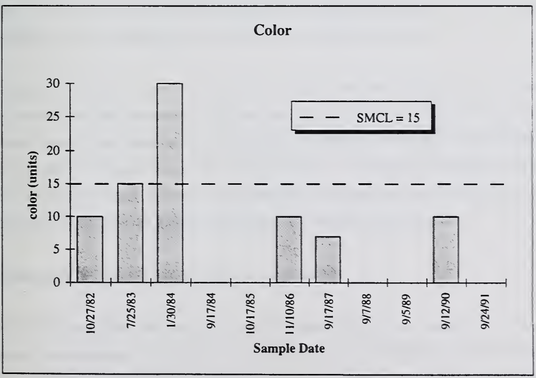
Source. SFWD annual reports submitted to DHS

FIGURE 6-8
RAW WATER QUALITY-
SAN ANDREAS RESERVOIR (a)

TIME SERIES AND STATISTICAL ANALYSES



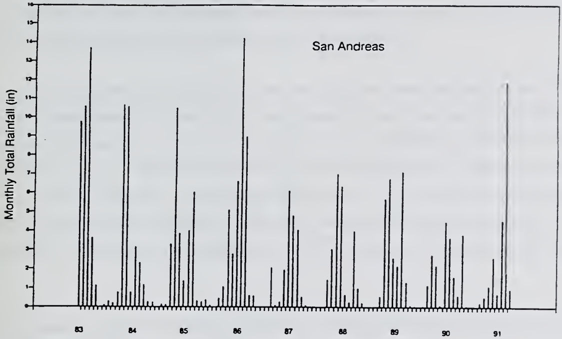
Turbidity	
Mean	1.9
Std Dev'n	2.1
Range	6.4
Minimum	0.4
Maximum	6.8
Number	12



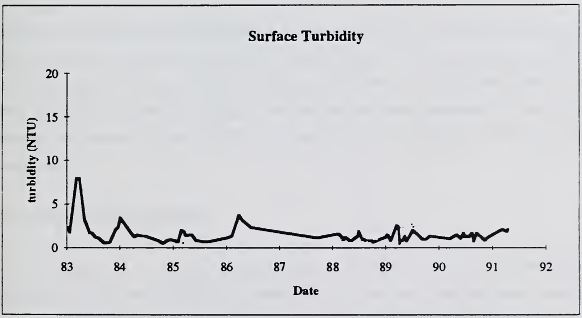
Color	
Mean	7.5
Std Dev'n	9.3
Range	30
Minimum	0
Maximum	30
Number	11

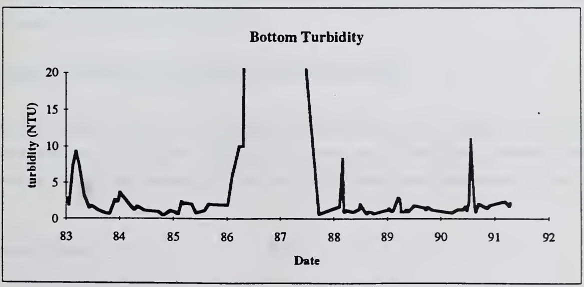
Source: SFWD annual reports submitted to DHS.
Note: (a) MCLs and SMCLs apply to treated water,NOT raw water, and are shown in this figure only for relative comparison with raw water quality.

FIGURE 6-9
SAN ANDREAS RAINFALL AND TURBIDITY
1983 to 1991



Peninsula Watershed Monthly Rainfall (a)





(a) DWR data. Rain gage at San Andreas Reservoir.

All raw water from Peninsula reservoirs is treated at the Tracy WTP to meet drinking water standards. Where possible, the raw water quality is compared with post-treatment data to verify that MCLs are being achieved in the water delivered to consumers.

The raw waters of the Peninsula reservoirs can have high raw water turbidity levels. The Tracy WTP treated water turbidity is monitored continuously through on-line turbidimeters and the operations staff monitor the treated water turbidity levels by collecting grab samples every four hours. Between January 1993 and January 1994, the average monthly treated water turbidities ranged from 0.04 to 0.07 NTU, as shown in Table 6-13. The average monthly removal rate through the plant was 88 to 98.3 percent. The plant had an excellent performance record for the year, with 98.4 to 100 percent of the samples <0.5 NTU each month, well above the required 95 percent.

Table 6-10 presents available asbestos information. Although the data is limited, the Tracy WTP appears to effectively remove asbestos from raw waters.

SFWD monitors disinfectant residual and total coliforms jointly in the distribution system, as previously presented in Tables 5-20 and 5-18, respectively. The disinfection residual was present in 98.8 percent to 100 percent of the samples each month, complying with the 95 percent requirement. Likewise, coliform sampling in the distribution system indicated 96 to 100 percent of the samples had absence as their results on a monthly basis, complying with the 95 percent absence requirement.

Projected Changes in Water Quality

There are no changes in water quality anticipated. However, the goal of the Watershed Management Plan project which SFWD is undertaking is to maintain and improve current water quality. As management strategies become more effective, SFWD may experience improved raw water quality in the Peninsula reservoirs.

EVALUATION OF SYSTEM'S ABILITY TO MEET SWTR

As discussed in Section Five, the SWTR stipulated that surface water supplies must undergo a multibarrier treatment to remove and inactivate waterborne pathogens, thereby providing consumers with reliable and redundant protection. EPA promulgated rules requiring the removal

TABLE 6-13

HARRY W. TRACY WTP TURBIDITY MONITORING

January 1993 to January 1994

	January	February	March	April	May	June	July	August	September	October	November	December	January
Raw Water													
Average Monthly Turbidity (NTU)	5.4	4.1	2.1	NR	0.94	0.9	0.78	0.5	0.55	0.6	0.65	1.1	0.68
Treated Water													
No. of Samples	184	165	180	176	186	176	186	186	179	186	178	185	186
No. of Samples < 0.5 NTU	181	165	180	176	186	176	186	186	179	186	178	185	186
Percent < 0.5 NTU	98.4%	100.%	100.%	100.%	100.%	100.%	100.%	100.%	100.%	100.%	100.%	100.%	100.%
Average Monthly Turbidity (NTU)	0.09	0.07	0.08	0.07	0.07	0.06	0.07	0.06	0.06	0.05	0.06	0.05	0.04
'erage Monthly Turbidity Reduction	98.3%	98.3%	96.2%	NR	92.6%	93.3%	91.%	88.%	89.1%	91.7%	90.8%	95.5%	94.1%

Source: SFWD operator logs.

NR: Not reported.

and inactivation of *Giardia lamblia*, viruses, heterotrophic plate count bacteria, *Legionella*, and turbidity through filtration and disinfection.

DHS determined that all surface waters in California are subject to potential contamination from *Giardia lamblia* and viruses. Tests for both *Giardia lamblia* and *Cryptosporidium* have yielded positive results in the San Andreas waters. A summary of historical microbiology is documented in the section *Description of Existing Water Quality,* and presented in Table 6-8.

In accordance with the SWTR, DHS requires 99.9 percent (3 log) reduction of *Giardia* cysts and a 99.99 percent (4 log) reduction of viruses, to be achieved through filtration and disinfection. Use of approved treatment technologies satisfies the SWTR requirements in lieu of confirmatory sampling data. Surface water supplies meeting the following filtration and disinfection requirements shall be deemed to be in compliance.

The Tracy WTP is effective at meeting all current regulations pertaining to the SWTR. More specific information on filtration and disinfection compliance is provided below.

Filtration

The rules promulgated by DHS state that filtration treatment must meet performance and operating criteria to comply with the pathogen removals specified above. The performance criteria are as follows:

- Turbidity of the filtered water shall be less than or equal to 0.5 NTU in 95 percent of the measurements taken each month.
- Turbidity shall not exceed 5.0 NTU at any time.
- For grab sampling monitoring, the filtered water shall not exceed 1.0 NTU in more than two samples taken in consecutive four hour intervals while the plant is in operation.

Table 6-13 presents turbidity data. Each month between 98.4 percent and 100 percent of the treated water samples had turbidity levels less than 0.5 NTU. Turbidity did not exceed 5.0 NTU during this time period. Finally, the filtered water from the Tracy WTP did not exceed 1.0 NTU in more than two consecutive samples.

In addition to performance criteria, filtration plants must meet operating criteria to comply with the pathogen removal and inactivation requirements of the SWTR. The operating criteria stipulate the following.

- Conventional and direct filtration dual media filters shall not exceed flow rates of 6.0 gpm/sf.

- The effluent from each filter shall be monitored for turbidity, continuously or with a grab sampling program approved by DHS.

- After an interruption event (e.g. backwashing, repairs, etc.) the performance of each individual filter unit shall not exceed the following:
  1) 2.0 NTU
  2) 1.0 NTU in at least 90 percent of the interruption events during any consecutive 12-month period.
  3) 0.5 NTU after the filter has been in operation for more than 4 hours.

- Coagulation and flocculation units shall demonstrate an 80 percent reduction of the monthly raw water turbidity through the filters.

The Tracy WTP has ten dual media filters, each with an area of 1,850 sq ft. At 180 mgd, if all filters are in service, this is a loading rate of 6 gpm/sf. SFWD is currently developing a petition, requesting that DHS approve a pilot study to measure the filter performance at flowrates of 6.875 gpm/sf. The monthly turbidity removal rates through the filters are shown in Table 6-13. They range from 88 percent to 98.3 percent, well above the required 80 percent reduction.

Disinfection

In order to satisfy the pathogen removal and inactivation requirements of the SWTR, disinfection treatment must also meet the performance and operating standards.

- Water delivered to the distribution system shall contain a disinfectant residual of not less than 0.2 mg/L for more than four hours in any 24-hour period.

- The disinfectant residual concentrations of samples collected from the distribution system shall be detectable in at least 95 percent of the samples taken each month, during each and every two consecutive months that the system serves water to the public. The disinfection

residual must be measured in conjunction with the total coliform sampling – at the same time and location.

The disinfection residual is monitored continuously at the point where treatment plant effluent enters the distribution system. Table 5-20 presents a summary of data on disinfection residuals throughout the distribution system between February 1993 and January 1994. Between 98.8 percent and 100 percent of the samples had a measurable residual, complying with the 95 percent requirement. The TCR states that each month, 95 percent of the total coliform samples collected throughout the distribution system must be negative. Table 5-18 displays the coliform sampling results. From February 1993 to January 1994 between 0 and 4.0 percent of the samples were positive, within the TCR requirement.

The disinfection operating criteria stipulate the following.

- A supply of chemicals shall be maintained as a reserve, or demonstrated to be available.

- In the event of disinfection failure, an emergency plan shall be developed for implementation to prevent the delivery of inadequately disinfected water.

The Tracy WTP Procedures Manual states emergency procedures in the event of a disinfection failure.

CONCLUSIONS

Peninsula reservoirs have generally good water quality. The raw waters in all Peninsula reservoirs have elevated turbidity levels, and the Tracy WTP is very effective and reliable at removing particulates so that the turbidity of the treated water meets drinking water standards. In few instances, sampling at Pilarcitos has yielded elevated readings of iron and manganese. There is no treatment plant effluent data on these parameters to verify removals through the plant; however, these are secondary standards which are aesthetically based.

Two of the Peninsula reservoirs exhibit seasonal behavior. Crystal Springs and Pilarcitos Reservoirs stratify in the summer. The thermoclines are located at 30 feet below surface, and the hypolimnion becomes anoxic from July to November. San Andreas Reservoir, on the other hand, is relatively shallow and remains mixed throughout the water column all year, with a short hydraulic residence time of approximately four months. The water is not stratified in the

summer, and dissolved oxygen is present throughout the water column for the entire year. The water in Peninsula reservoirs contains sufficient nutrients (nitrogen and phosphorus) to sustain algal blooms, one to four times a year. SFWD has been effective at reducing the amount of copper sulfate used for control. From available data the Tracy WTP is effective at meeting all current regulations pertaining to the SWTR. Recommendations concerning water quality can be found in Section Ten.

SECTION 7

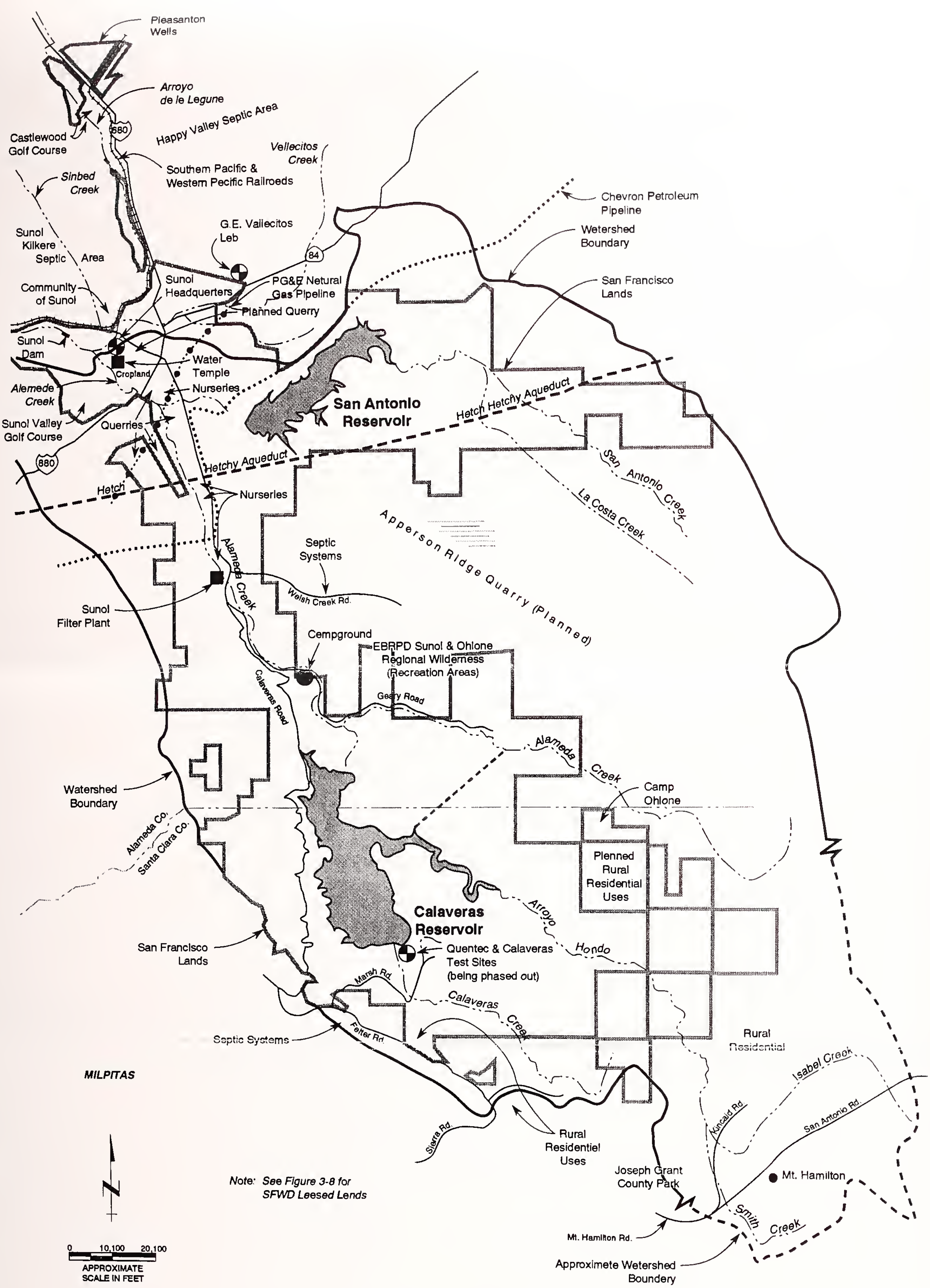
POTENTIAL CONTAMINANT SOURCES WITHIN ALAMEDA WATERSHED

Almost all urban and rural land uses have a potential for contaminating watershed water supplies given the circumstances, therefore a description of the primary land uses and activities within the watershed is provided here. This section, and Section Eight, may be used by DHS and SFWD to aid in identifying the source of a particular water quality concern which unexpectedly appears at the reservoirs or treatment facilities and/or to identify areas of potential contamination which need a proactive effort.

POTENTIAL CONTAMINANT SOURCES

The land uses and activities occurring within the watershed which have the potential for impacting water quality are both natural features (e.g. fires, sedimentation, mammals) and human-induced activities (e.g. roads, recreation). The following activities and land uses are described below. Most of the land uses discussed here are presented in Figure 7-1. Photographs of the Alameda watershed are provided in Appendix A.

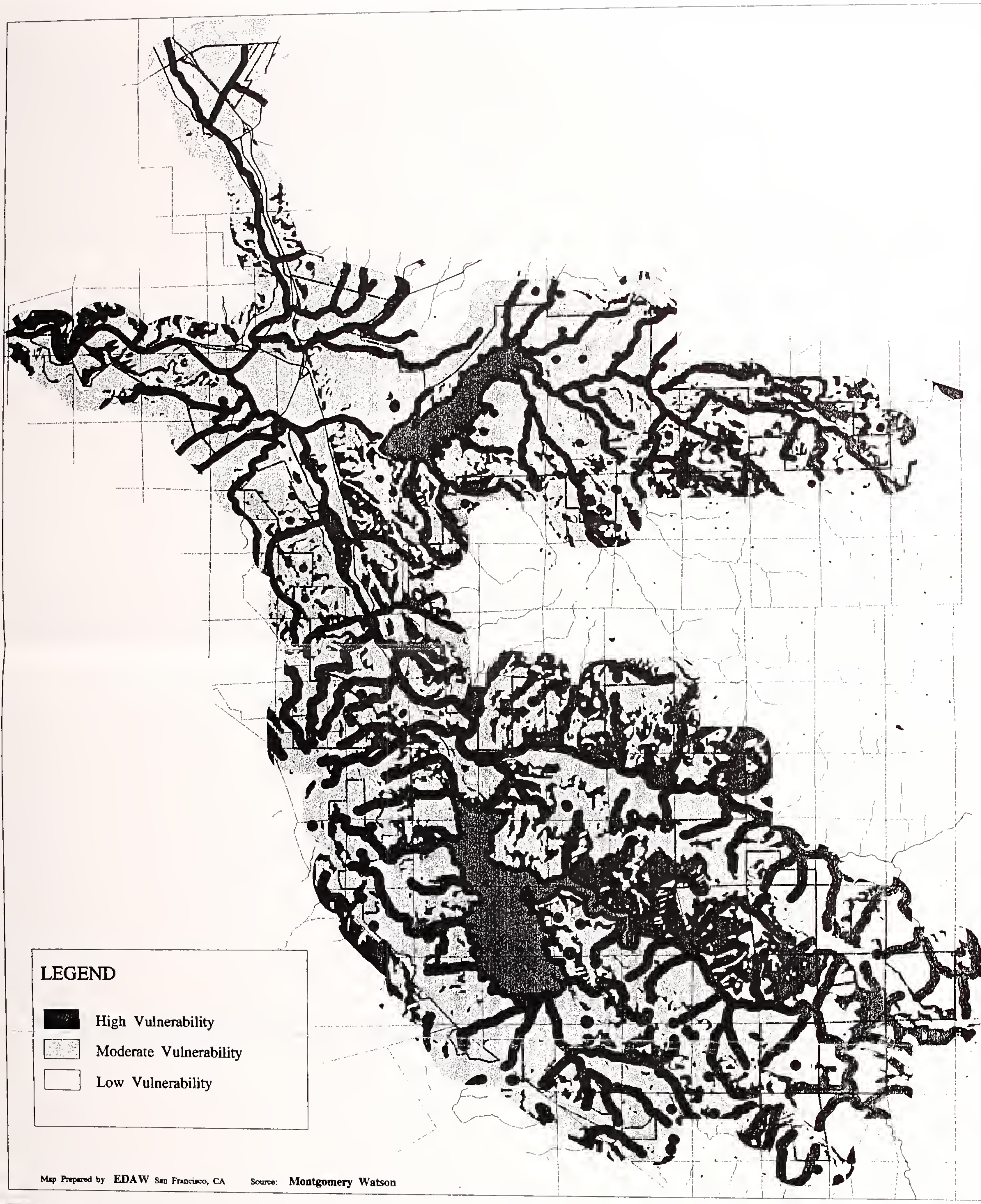
- Automobile Corridors
- Railroad Alignments
- Utility Corridors
- Recreation and Research
- Sunol Valley Golf Course
- Sanitary Facilities
- Residential Areas
- Wildlife and Livestock
- Nurseries
- Quarries
- Industrial Uses
- Natural Resource Management
- Other SFWD Operations



Note: See Figure 3-8 for SFWD Leesed Lends

LAND USES WITHIN ALAMEDA WATERSHED

FIGURE 7-1



Water Quality Vulnerability Zones for Particulates

A L A M E D A W A T E R S H E D
SAN FRANCISCO WATERSHED MANAGEMENT PLANS

FIGURE 7-2

Automobile Corridors

Within the watershed there are approximately six miles of Interstate highway and ramps, 10 miles of state highways, 30 miles of paved roads and streets, 90 miles of unpaved roads, and many miles of dirt roads and jeep trails. I-680 parallels the Arroyo de la Laguna south until it crosses the Alameda Creek in the Sunol Valley. Highway 84 runs adjacent to Alameda Creek through Niles Canyon, across I-680 and on to the west towards Livermore, crossing a small tributary to San Antonio Reservoir. Calaveras Road is a county road that starts at I-680 and parallels Alameda and Calaveras creeks south past Calaveras Reservoir and leaves the watershed to the west. Other primary public roads within the watershed include Marsh, Ranch, Felter, Kincaid, Welsh Creek, and Geary Roads.

In addition, SFWD maintains access roads throughout the watershed for fire access, watershed maintenance, and security purposes. Most of these roads are dirt roads with some sections of gravel surfacing generally following routes of old cattle trails. Prior to each fire season, the access roads are regraded. Access is limited to SFWD personnel, lessees, and landowners who must cross SFWD lands to reach their property.

Concerns related to these transportation corridors include 1) road surface runoff of copper, lead, zinc, oil and grease, and polycyclic aromatic hydrocarbons from leaks, spills, and general automobile usage, 2) fire danger as a result of auto accidents, parking on road shoulders, and un/intentional ignition from thrown cigarettes, matches, etc., 3) herbicides applied during roadside maintenance, 4) illegal dumping and trespassing, and 5) rapid runoff and increased erosion due to poor road design and maintenance practices.

Surface Runoff. In 1993, an average of 97,000 vehicles per day used I-680 in the vicinity of the intersection with Highway 84; an average of 12,500 vehicles per day used Highway 84 through Niles Canyon and 11,000 vehicles per day on the Vallecitos Road portion of Highway 92 (Alameda County, 1994). Approximately 90 vehicles per day use Calaveras Road. Since 1989, the California Highway Patrol has prohibited trucks carrying hazardous materials from traveling through Niles Canyon. The northwest end of Calaveras Reservoir is most vulnerable to spills since Calaveras Road passes nearest the reservoir at this point. Depending on the toxicity of the substance spilled, the consequences may include killing of aquatic life in the tributary or in part of the reservoir, and it may impact the ability of SFWD to use the water from the reservoir for some period of time. A spill along the roadside not entering surface waters could be cleaned up by excavation and removal before affecting the reservoir water quality and is therefore not

[illegible]

[illegible]

[illegible]

[illegible]

likely to have a long term impact on the watershed. Calaveras Road, however, has a low design standard and has limited truck usage. Even if vehicles are not transporting hazardous materials, accidents may result in gasoline and engine coolant spills.

Fire Risk. Fire created by activities along the roadside could have significant negative impacts on the water quality of the reservoir due to the large increase in the amount of sediment and organic matter that would be introduced due to increased erosion during rainfall events. This is one of the most important potential contributors to water quality deterioration within the Alameda watershed. Fire danger is discussed in more detail in the section on natural resource management.

Herbicides. Highway maintenance along the main corridors include the spraying of herbicides to control vegetation. Herbicide application is done to: 1) create a fire break, 2) maintain the integrity of the pavement, 3) maintain site distance around curves, and 4) allow safety devices to remain visible. A soil acting product containing the active ingredient diuran (product names Carmex or Diurex) is applied once a year in the fall to act as a barrier to germinating seeds. Roundup (active ingredient glyphosate) is applied during the growing season as needed for touch up; Roundup is a contact defoliant and does not create runoff. There is no available data on the volumes of herbicides sprayed along the roadsides within the watershed or the impacts of these chemicals on water quality. The half life of Roundup is less than 30 days.

Dumping. Illegal dumping and trespassing may impact the reservoir water quality by introducing contaminants from materials dropped into creeks leading directly into reservoirs. The illegal dumping of household wastes and appliances as well as carcasses occurs within the Alameda watershed primarily along Calaveras Road. A number of incidents of human bodies being dumped at the south end of Calaveras Reservoir have occurred. This area does not have a watershed keeper cottage and is therefore more difficult to patrol. Illegal dumping will likely increase in the future as the Bay Area population continues to increase.

Erosion. The impact of the access roads is predominantly through the production of sediment due to rapid runoff and subsequent erosion. Many miles of access road within the watershed are graded with a ditch to the inside of the road against the hill slope. This concentrates runoff within the ditch and forms gullies both along the road and downhill slopes where runoff leaves the road. Culverts built to channel the water under roads have created gullies up to two feet in depth. At locations where roads cross streams, each road acts as a source for sediment eroded from the road and transported directly into the stream. No specific estimates are available on the

[illegible]

[illegible]

[illegible]

[illegible]

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[illegible]

amount of sediment being produced per mile of roadway; the amount of sediment will vary according to the steepness of the grade, soil type, usage, maintained condition, and original design.

Railroad Alignments

One active railroad track is located within the study area - the Union Pacific track parallels Highway 84 through Niles Canyon on the south side of Alameda Creek, then parallels and crosses Arroyo de la Laguna, and dissects the Pleasanton well field as it heads east. Union Pacific reports that approximately 12 to 16 Union Pacific or Southern Pacific trains move through the canyon each day on this track. Train lengths vary from 10 to 100 cars. In addition, a parallel track on the north side of Alameda Creek, which is an abandoned Southern Pacific line, is operated for recreational purposes between the communities of Niles and Sunol.

The greatest concern with the Union Pacific alignment through the watershed is associated with accidental spills of harmful materials. According to the California Public Utilities Commission, no major derailments have occurred in the Alameda watershed since 1980, however, a spill occurred on the Union Pacific route in 1994 in the City of Fremont. The potential contaminants that could be spilled into the Alameda Creek are large and varied. The Commission indicates that large amounts of hazardous materials are carried from San Jose to the Central Valley along this line (ACWD, 1990). A major derailment or vandalism could result in a release to Alameda Creek. The worst case scenario would be a hazardous liquid tank car falling from the tracks and rupturing, spilling its contents directly into Alameda Creek. The precedent for large scale contamination is evidenced by the derailment and spillage of metamsodium from the well publicized train accident at Dunsmuir, California in 1991.

Utility Corridors

Within the watershed exists petroleum and natural gas pipelines operated by utility and private companies. The Chevron Pipe Line Company (Chevron) operates a pipeline that transports refined petroleum products from the Bethany Pump Station (near City of Tracy) to a terminal in San Jose. The pipeline runs through the San Antonio Reservoir watershed and runs south parallel to and then crosses Calaveras Road and Alameda Creek in the Sunol Valley; another line, owned by Santa Fe is located west of the Sunol Temple. The section of Chevron pipeline crossing the watershed was installed in 1965 and is an 8-inch welded steel pipe which is externally coated, cathodically protected, and operates with a leak detection system in

accordance with the U.S. Department of Transportation codes and standards. Approximately 3.3 miles of pipeline lie within the reservoir watershed, passing within 2,000 feet of the main body of water at its closest point, near pipeline milepost 79. It passes under Alameda Creek near milepost 83.3, just north of the Sunol WTP. The major causes of failure for this type of pipe are 1) damage caused by excavation (single largest cause), 2) corrosion, 3) external loading, 4) operations, 5) landslide or earthquakes. There is no record of pipeline failure on this pipeline and no reported leaks. One landslide has occurred but the pipeline did not fail. In addition, another petroleum pipeline crosses though the watershed along Arroyo de la Laguna, past the Sunol headquarters, and continues south out of the watershed. These pipelines are located in Figure 7-1.

The worst case scenario for a spill into San Antonio Reservoir would be 500 barrels (21,000 gallons) of refined petroleum products, and 780 barrels (32,760 gallons) spilling into the Alameda Creek. These estimates are based on the response time to close valves, the distance between high points that would drain out if the pipeline were ruptured at the low point, and the depressurizing of the pipeline. In the absence of new valves, the spill into Alameda Creek could be 868 barrels of product; with the proposed valves and check valves it could be 346 barrels. Spilled oil would affect the soil, groundwater, and surface waters. The water supply from San Antonio Reservoir and Alameda Creek would be affected immediately and unusable until the spill had been contained and cleaned up. Short term impacts to the surface waters could include fish kills. Long term impacts to soil and groundwater would need to be assessed and remediated. Contamination of the groundwater could have an impact on the usability of the groundwater for many years.

Chevron plans to reroute the segment of pipeline that runs east of the Alameda Creek crossing; the current alignment is parallel to the Calaveras fault and is vulnerable to seismic compression. The pipeline will be rerouted to the ridge east of the creek to reduce seismic vulnerability. About 3.5 miles of pipe east of the creek crossing will be removed and four miles of new pipe installed along the ridge. The new segment will include two remotely activated shutoff valves and two check valves. Chevron has started the permitting process.

In addition, PG&E operates low pressure gas lines which run parallel to the south side of the electric power transmission lines that cross watershed lands north of San Antonio Reservoir, as shown in Figure 7-1. These gas lines cross San Antonio Creek and Alameda Creek near the intersection of Calaveras Road. If the natural gas lines were to rupture during dry weather, it may result in a fire which would result in significant sedimentation impacts to the water bodies.

Recreation and Research

Recreation within the watershed is restricted to lands owned and leased by the East Bay Regional Park District (EBRPD) and the Sunol Valley Golf Course which is described below. Other informal recreational activities occur upstream of Calaveras Reservoir in Santa Clara County outside of the SFWD-owned lands; in particular, at the Joseph D. Grant County Park, which is located along Mt. Hamilton Road. The Alameda Water Temple at the Sunol headquarters is currently closed to the public. Permits are granted by SFWD for research on lands it owns.

Recreational activities at the Sunol and Ohlone Regional Wilderness', operated by EBRPD, include picnic and overnight backpacking facilities (including group facilities), extensive pedestrian, equestrian, and bicycle trails, naturalist-led weekend programs, and special events including a wilderness fair and running races. Approximately 200,000 persons per year use the park. The Sunol Wilderness is approximately 5,900 acres and the Ohlone Wilderness is about 6,800 acres. It is located north of Calaveras Reservoir along Alameda Creek; access is provided from Geary Road which is off of Calaveras Road. The 29-mile Sunol-Ohlone Wilderness Trail crosses through the watershed lands. This trail starts at Mission Peak, runs through the day use facilities on Geary Road, and continues east to Del Valle Regional Park. Permits for backpacking are granted by EBRPD for use at Camp Ohlone, High Valley Camp, and School Camp. Activities in the wilderness area that may contribute as potential sources of contamination include 1) offtrail hiking and cycling causing erosion, 2) improperly placed trash and vandalism, 3) microorganisms associated with human, equestrian, and pet wastes, 4) vehicle related contaminants, and 5) increased risk of fire. The most serious potential impact is associated with the increased risk of microorganisms getting into water bodies. Sanitation facilities are discussed later under sanitary facilities. There is no information available regarding park users who do not use the sanitation facilities.

Permitted access on SFWD lands outside of that leased by EBRPD is controlled by the Watershed Management and Alameda groups of the SFWD. Access is limited to government agencies or other groups conducting research and for natural resource study and data collection. Permits are not issued for recreational activities. Groups requesting a day use permit must submit a written request describing the use, duration of use, and the benefit to the watershed. If the request is granted, the user must pick up a permit at the Sunol headquarters and sign the permit and hold harmless clauses. Specific activities that could be the source of potential contaminants include members of research teams who may disturb vegetation and leave trails

[illegible]

[illegible]

[illegible]

[illegible]

thus increasing the potential for erosion, and additional people in the watershed increasing the risk of fire.

Sunol Valley Golf Course

The Sunol Valley Golf Course management leases 713 acres between I-680 and Highway 84 in the Sunol Valley from SFWD. The estimated number of users is 88,400 per year. The terms of the Sunol Valley Golf Course lease do allow for revisions to land use and landscape management practices. The Watershed Management Plan, under development, will provide SFWD with guidance for developing lease clauses for prescribing land use or management practices to reflect the policies of the Plan. A discussion is provided here on general golf course management and potential contaminant sources, including fertilizers, pesticides, and vehicle related pollutants. Specific site information is not available; data should be collected and reviewed to determine the potential for pollution generated at this facility.

Fertilizers. The use of fertilizers is necessary to avoid nutrient deficiencies and so maintain acceptable turf grass growth and aesthetic quality at golf courses. Nitrogen, potassium, and phosphorous are the most common turf grass fertilizers. Turf grass growth and color are most responsive to nitrogen fertilization. Nitrogen levels in soils tend to decrease over time, and therefore regular additions of nitrogen are required. Potassium is also required in relatively large amounts to improve root growth, increase tolerance of climate extremes, and reduce susceptibility to disease. Phosphorous enhances seed establishment and increases root growth, however phosphorous deficiency does not occur as often as nitrogen or potassium deficiencies. Sulfur, calcium, magnesium and micronutrients are the other essential elements to turf grass management. Of these, only sulfur deficiency occurs as frequently as the nitrogen and potassium deficiencies, and therefore requires frequent application. The concerns with fertilizer applications include the following.

- Improper use in drinking water supply watersheds may affect surface water quality;

- Relatively high application rates with little mixing, compared to agricultural systems, increases the potential for increased surface runoff; and

- Use in well-drained soils may promote leaching of nutrients to groundwater, and potentially to nearby surface waters.

Nitrogen is the nutrient of most concern to water quality because of the production of highly mobile nitrate from fertilization, and its heavy use on well-drained soils such as putting greens, that tend to leach readily. Nitrogen's subsurface movement from turf grass is of particular concern to nearby groundwater supplies. Nitrogen may also be transported from turf grass via volatilization, denitrification, removal and off-site disposal of grass clippings, and surface runoff (Petrovic, 1990). Of these pathways, surface runoff has the most immediate impact to surface water bodies and can result in changes to ecosystem productivity, i.e. eutrophication. Fertilizer transport in surface runoff may be affected by a number of factors including precipitation, soil characteristics, fertilizer management practices (e.g. formulation, application rate, timing, and placement), and soil management practices (e.g. erosion control, buffer strips, irrigation).

Pesticides. The maintenance of color, uniformity, and density in non-native turf grasses is often adversely affected by weeds, disease, and insects. Also, turf grass diseases are a significant problem because of close mowing, intense irrigation, high fertilizer application rates, and constant injury from foot traffic and divots. As a result, the use of pesticides is critical to the maintenance of golf courses (Kriner, 1985). The pesticides listed in Table 7-1 were used at the Sunol Valley Golf Course in 1993.

TABLE 7-1

PESTICIDE USAGE AT SUNOL VALLEY GOLF COURSE

	Name	Quantity
Herbicides		
	Amine-4 24D	2 gallons, 1 quart
	Banvel	96 ounces
	Roundup	40 pounds, 8 ounces
Insecticide		
	Dursban 2E	6 gallons
	Dursban 50W	22 pounds
Fungicide		
	Cleary's 3336	12 pounds
	Fore	720 pounds
	Subdue 2E	5 gallons

Source: SFWD, 1993.

[illegible]

Pesticides begin to disperse immediately after application via volatilization, adsorption, decomposition, and water transport. Pesticide transport in surface runoff may in turn, be affected by a number of factors including: rainfall characteristics, time since application, pesticide chemical properties, application rate and method, degradation rate, soil properties, moisture conditions, ground cover, and transport distance. Several studies indicated that the greatest loss of pesticides results from storms that occur soon after initial applications. In some cases, the potential for pesticide loss in runoff from turf grass may be greater than from agricultural systems (Watschke et. al., 1988). Although the effects on water quality from pesticide use on agricultural lands and aquatic organisms have been established, the effects from pesticide use on turf grass are not well documented. Survey studies of pesticide presence have shown that heavily used, persistent, and relatively soluble pesticides tend to appear more frequently in surface waters.

Vehicle Related Pollutants. In addition to automobiles transporting golfers to the facilities, there are two sources of vehicle related pollutants at golf courses: golf carts and maintenance vehicles. Both types of vehicles generate pollutants through their use and service. Pollutants may be released via fueling, fluid removal/replacement, washing, leaks, and spills. The specific pollutants generated by vehicles are oils, greases, heavy metals, petroleum hydrocarbons, and polycyclic aromatic hydrocarbons.

The degree to which golf carts are of concern depends on their type, gas/diesel or electric. Gas/diesel-powered golf carts are of more concern because their technology (i.e. internal combustion engine) requires the use of more fluids (e.g. fuels, lubricants, battery acid) than electric powered motors. Maintenance vehicles (tractors, mowers, spreaders) are typically gas-powered.

Although pollutants can be generated by golf carts and maintenance vehicles anywhere on a golf course via leaks and spills, the area of most concern is the service area. Activities that can generate pollutants at the service area, particularly if the activity is conducted outside, include fueling, fluid removal/replacement, washing, material storage, and hazardous waste storage. The areal extent, pollutant loading, and risk level from pollutants generated by leaks and spills from vehicles (golf carts and maintenance vehicles) on the golf course itself is probably minimal. The lack of servicing activities occurring on the golf course, as opposed to the maintenance shop, and the infrequent occurrence of leaks and spills reported, means that the impact from general vehicle use on the golf course is probably minimal. No golf cart usage rates were available for the Sunol Valley Golf Course.

Sanitary Facilities

There are numerous sewage facilities located at the watershed cottages, at water system operations facilities, and at recreational sites. There are also residential areas on septic systems upstream of the Calaveras Reservoir and near Arroyo de la Laguna, adjacent to the study area to the north.

Sewage Facilities. The watershed lands are patrolled by watershed keepers who live in cottages within the watersheds. The cottages are equipped with toilets that discharge to sewage vaults which are partially pumped on an average of twice weekly, using a 5,000 gallon waste tanker that is operated by SFWD. There are two cottages at Calaveras Dam with a vault size of 12,500 gallons each; a cottage is located at Turner Dam and has a vault with a capacity of 10,000 gallons; a cottage at the East Portal along Calaveras Road has a vault capacity of 7,500 gallons. There are no leach fields associated with the vaults.

Sanitation facilities are also provided at system facilities and for construction activities. Presently there are chemical toilets at the Calaveras Tower, San Antonio Lake, and the old chlorine building below the base of the Calaveras Dam. These chemical toilets are serviced by a contractor, but they are not serviced on a regular schedule. SFWD also has a trailer with a chemical toilet that is used by SFWD staff and contractor work crews in the Alameda watershed. The trailer-mounted chemical toilet is serviced by the same SFWD truck that services the sewage vaults at the watershed keeper cottages.

An old pit facility at the hunting camp in the Calaveras reservoir drainage basin has been replaced with a new portable facility. The pit facility has been secured and the site restored. SFWD is preparing an agreement with the landowner to ensure regular maintenance of the new facility.

The Sunol Regional Wilderness maintains 25 chemical toilets and five permanent toilets with vaults. The chemical toilets are pumped out weekly and the toilet vaults are pumped out on an as needed basis. Four of the permanent toilet facilities are located in the Camp Ohlone campground. The fifth is located in the High Valley area of the park which is also used for permitted overnight camping. The park hosts several special events including a wilderness fair and some running races. Some events are required to provide additional chemical toilets if the anticipated attendance of the events is large. According to EBRPD, approximately 200,000

persons per year use the park and less than 10 percent of these people use the permanent toilet facilities. It is assumed that the remaining people use the chemical toilets or no facilities at all.

Since the sewage vaults and chemical toilets are frequently pumped out, the sanitation facilities within the watershed appear to pose a low risk to the reservoir and creek water quality. However, there are increased risks of accidental spills as the automobile traffic within the watershed increases which could interfere with the waste tanker on public roads, and as the recreational facilities are utilized more in the future and vandalism to the holding tanks occurs.

The Sunol Valley Golf Course has a small wastewater treatment facility for the estimated 88,400 annual golf course users. The head greens keeper is responsible for the operation and maintenance of the treatment plant and is a certified operator. This treatment facility handles flows of about 12,000 gallons per day from the golf course facilities. Treated effluent is stored in a holding pond with a 30-day capacity. The treated effluent is diluted with irrigation water from Alameda Creek and used to irrigate the golf course grounds. The Sunol Valley Golf Course sewage treatment plant meets the Regional Water Quality Control Board permit requirements. The RWQCB inspects the facilities twice a year and according to the plant operator no violations have been reported.

The quarry operations and nurseries in Sunol Valley are all on either chemical toilet or vault systems. These facilities are pumped out by a private contractor for the leases.

Septic Systems. There are scattered rural residential uses along Welsh Creek Road near the Sunol WTP, and south of Calaveras Reservoir within the watershed on privately owned lots. These homes are on individual septic systems with leach fields and/or septic tanks. According to the Santa Clara County Department of Public Health and the University of California at Santa Cruz - Environmental Health and Safety Office, there are approximately 110 registered septic systems within the watershed: 65 systems around the southern end of Calaveras Reservoir on and near Felter Road; 29 systems around Mt. Hamilton/San Antonio Road, Kincaid Road, and within Grant Park; and 16 systems at the Mt. Hamilton Observatory on university lands. These numbers may be low because the county began registering systems in 1955 and has no record of previously built systems. The above described areas do not appear to have significant problems with system failures. As these areas continue to develop with low density homes, additional septic systems will be added within the watershed which will increase the risk of effluent contamination from system failure.

To the north of the watershed, adjacent to Arroyo de la Laguna and Sinbad Creek, are two rural areas on septic systems, Happy Valley and Sunol-Kilkare areas. Happy Valley is sited in the Regional Water Quality Control Board's Water Quality Control Plan as being a problem area. During the mid-1970's, a construction ban was placed on development within Happy Valley because of public health concerns related to high nitrate concentrations. This area is being watched by the Alameda County Environmental Health Department. Since the Sunol-Kilkare area is close to SFWD's Filter Galleries, this area is also being watched by SFWD and the County.

Residential Areas

As mentioned above, there are existing rural residential "ranchettes" located along Welch Creek Road and south of Calaveras Reservoir. Many of these residences are on large parcels and have landscaping, structures, and often horses, cattle, and other animals. The potential contaminants associated with the ranchettes are pathogens from effluent from failed septic systems, pathogens from livestock and pets, chemical and fertilizer usage on landscaping, chemical usage within the home, sedimentation from construction activities, oil and grease from automobiles, and an increased risk of fire and vandalism.

Wildlife and Livestock

In addition to the natural wildlife which exists within the watershed, the Alameda watershed also has extensive amounts of land utilized for cattle grazing. Wildlife and livestock have the potential to generate nutrients, pass along microorganisms, and increase erosion of sediment. Although some information is known about microorganisms and nutrients associated with livestock, less is known of other animals. A brief description is provided here of wildlife and livestock known or likely to exist within the watershed and of the potential contaminants associated with wildlife and livestock. It should be noted that microorganisms and erosion are also associated with humans.

The Alameda watershed is within the Pacific Flyway and provides winter foraging and resting habitat for migrating and resident bird species, attracting raptors, waterfowl, and passerine bird species. The watershed provides wildlife habitats in the non-native grasslands found on south-facing slopes, coast live oak woodlands in ravines, blue oak woodlands on north-facing slopes, and coastal scrub on south-facing slopes. Riparian habitat occurs along the major creeks tributary to the reservoirs. Beaver are known to exist in several tributaries, and ponds throughout

the watershed are potential habitat for western pond turtle, red-legged frog, foothill yellow-legged frog, and the California tiger salamander. Bats have been found in the entrance to the Alameda Diversion Tunnel. Drier hill slope areas vegetated with coastal scrub, provide potential habitat for the Alameda whipsnake and the coast horned lizard.

Heavy cattle grazing on the grasslands surrounding San Antonio Reservoir has led to an abundance of ground squirrels that provide prey for a large concentration of raptors including golden eagles, black shouldered kites, ferruginous hawks, and sharp-shinned hawks. The grasslands are also host to the California horned lark, loggerhead shrike, burrowing owl, and short-eared owl. Nesting areas are found along inlets of San Antonio Reservoir for Great Blue Heron and Western grebe. A herd of approximately 65 Tule elk, introduced around Mount Hamilton, now forage along the hills that ring the southern edge of the reservoir. Recently the California Department of Fish and Game has designated the San Antonio grasslands area as potential habitat for the San Joaquin kit fox, a state threatened and federally endangered species. The open rolling grasslands and abundant ground squirrel burrows provide good habitat features for this species. The hillsides and tributary ravines around Calaveras Reservoir are foraging grounds for feral pigs. The Department of Fish and Game and the EBRPD entered into agreements with SFWD to conduct a feral pig control program. The program was implemented in July of 1995 and has resulted in over 350 animals removed to-date from SFWD watershed lands.

Livestock grazing is the dominant land use in the Alameda watershed, both within SFWD owned lands and upstream. Approximately 90 percent of SFWD lands, 26,500 acres, within the Alameda watershed are available for grazing (see Figure 3-7), and much of the land upstream of the Calaveras Reservoir outside of the SFWD lands is grazed. Historically, approximately 35,000 AUM (Animal Use Months, a livestock density measurement unit) have been permitted on SFWD-leased lands. This level has been significantly reduced to 23,900 AUM in 1994. The cattle currently have access to the reservoir tributaries; controls are being developed and some fencing is being constructed to enforce restricted access to the reservoirs. The terms of the grazing leases do allow for revisions to prescribe livestock densities and other range management practices. A Range Management Plan was developed to provide SFWD with guidance for modifying and managing grazing leases to reflect the policies of the Watershed Management Plan and to provide monitoring recommendations. A draft of the Range Management Plan was provided to DHS with this report; comments from DHS will be incorporated into the final plan. This plan will aid in the complete transition to an animal unit month-based grazing system. The SFWD Watershed Management section staff supervise the range management activities.

Nutrients. Nitrogen and phosphorous are found in animal waste. These nutrients can contribute to the eutrophication of water bodies and excessive algal growth. These effects, in turn, can reduce dissolved oxygen levels and result in fish kills. Increased nutrient levels also increase treatment costs including increased filter backwashing, taste and odor control, and copper sulfate use. The use of chlorine as a disinfectant increases the risk of generating THMs, a human carcinogen, and copper sulfate causes problems for wastewater treatment plants in meeting effluent limitations. Filamentous algae grow abundantly in submerged areas along creek beds, particularly those disturbed by animals. The algae grow during the wet season and are flushed downstream during the next wet period after drying out during the intervening dry period. Algae can be a significant nutrient input to the reservoirs. Copper sulfate is added to the reservoir water bodies up to two times per year depending on the need, to prevent or control algae blooms.

Microorganisms. There are many microorganisms (bacteria, viruses, and protozoa) transmitted by water which are associated with wildlife and livestock. Of these *Giardia lamblia* and *Cryptosporidium* have been the subject of attention recently as public water supplies have been implicated in outbreaks in several areas of the United States. Coliform bacteria is also of concern and is used as an indicator of the presence of other pathogens. *Giardia* is the most frequently identified pathogenic intestinal protozoan and the most commonly implicated agent in waterborne disease outbreaks in the United States. *Giardia* is prevalent in the waste of animals, in particular beaver and other aquatic mammals. Birds are a potential source of *Giardia* also. *Cryptosporidium* has been documented as the causative agent in several waterborne disease outbreaks. *Cryptosporidium* has been a recognized cause of disease in domestic cattle and poultry for years. These animals also act as reservoirs for the organism. Most important, cryptosporidiosis has been identified as a very severe disease in individuals with compromised immune systems, in some cases leading to death. At present, there is no known effective treatment for cryptosoridiosis. *Cryptosporidium* is much more resistant to disinfection with chlorine than is *Giardia.*

Coliform bacteria, fecal coliform and fecal streptococcus, is also typically found in animal waste. It not only is transmitted through the water, but it is known to settle out into the sediment on a stream bottom and be resuspended at a later date.

As discussed in Section Five, SFWD samples the two reservoirs for these pathogens and has detected them in several samples. Since disinfection and filtration of waters do not necessarily

eliminate *Giardia* and *Cryptosporidium*, any amount found in the untreated waters increases the risk of it remaining through the treatment process. *Cryptosporidium* is not currently regulated under the Safe Drinking Water Act but is anticipated to be regulated through treatment requirements in the near future (2 to 5 years) as microorganisms continue to increase in importance.

Erosion. Animals can compact soils which reduces stormwater infiltration; the resulting increase in runoff then increases the erosion of soils. Animals also reduce vegetation which decreases the organic matter content of the soil thus reducing soil porosity, and leaving the soil more vulnerable to erosion from rainfall. Rill and gully erosion may be initiated or increased by grazing and animal trails. Animals accessing streams disturb stream channel sediments and destroy riparian vegetation. The loss of riparian vegetation can alter channel geomorphology leading to higher velocity flows with greater erosive power. The increased sedimentation in the water bodies reduces the receiving reservoir capacity, causes high turbidity which must be treated at the treatment plant, and it adsorbs and transports other pollutants to the reservoir. A survey conducted in 1990 found that the greatest amount of grazing induced sedimentation occurred in the areas around Calaveras Reservoir and Calaveras Creek. Sedimentation impacts to water quality are discussed in more detail under natural resource management.

More specific information is needed if the numbers and locations of wildlife concentrations are desired. Baseline water quality monitoring for SFWD-owned and upstream lands is needed to determine the source locations of pollutant loadings to the reservoirs and the risk associated with the presence of wildlife and livestock in the watershed.

Nurseries

There are eight nurseries which presently lease land in the study area adjacent to Alameda Creek, downstream of the two reservoirs. Three of these are primary lessees while five of the nurseries sublease land from the primary lessees. Pacific Nursery, Naka Nursery, and Valley Crest Tree are the primary leaseholders. Not all of the leased land is currently being used for nursery uses. There are 186 acres being used for nurseries at the present time. The terms of the nursery leases do allow for revisions to prescribe land use and management practices. The Watershed Management Plan, under development, will provide SFWD with guidance for developing lease clauses for prescribing land use or management practices to reflect the policies of the Plan. The Sunol Valley Resource Management Plan, being developed as a part of the Watershed Management Plan, will provide additional detail regarding the current and recommended land

use practices of the nursery operations. The nurseries have potential sources of contamination from the fertilizers, herbicides, and pesticides used, and the compacted or paved impervious surfaces reducing infiltration and increasing peak runoff.

SFWD recently conducted a survey of nursery practices; six of the eight nurseries responded. Growers report growing plants ranging from bedding plants to boxed trees, and there is one three-acre orchard reported. Some of the nurseries obtain treated water from the Sunol WTP; all of the nurseries receive irrigation water from raw water lines. Approximately 132 acres (68 percent) are reported to be under drip irrigation, 26 acres (13 percent) are under conventional sprinkler irrigation, 33 acres (17 percent) are hand watered, and three acres (2 percent) receive one annual furrow irrigation. Eight acres at Hi-C Nursery were reported to receive both spray irrigation and hand watering; thus 194 acres are reported for the various types of irrigation, but only a total of 186 acres is in production. Since water use is metered but not billed, only two of the growers know their annual water consumption. Most growers report that they irrigate based on plant need, the weather, visual inspection of the stock, and their experience. The two nurseries that reported water usage are Dell's Ivy Acres and Pacific Nurseries. Dell uses about 1.6 ac-ft/yr per acre of production using overhead irrigation, while Pacific Nurseries uses three ac-ft/yr using both drip and overhead systems. Dell's is estimated to be applying water at a rate of about 38 percent of the annual evapotranspiration rate and Pacific Nurseries is estimated to be applying water at about 70 percent. Since both of these nurseries' water usage rates appears to be well within the evapotranspiration requirements of their crops, significant runoff is unlikely since excess irrigation does not appear to be occurring. Since 68 percent of the total nursery acreage is watered by drip irrigation; drip irrigation systems usually apply irrigation at rates too low to create substantial runoff. None of the growers reported substantial irrigation or storm runoff.

All nurseries report that they fertilize their stock. Fertilizers used include liquid nitrogen, potassium, and a chelate. Three of the six nurseries, representing 20 percent of the acreage, incorporate fertilizer into the soil or container, while 80 percent of the acreage is fertilized using fertilizer injected into the irrigation water. Growers report using a wide variety of fertilizer products as well as varying rates of application. The grower who incorporates the fertilizer into the container potting mix reports using about 0.63 tons per acre annually while the other growers incorporating the fertilizer into the field soils report the use of only 0.1 to 0.5 ton per acre annually. Growers using daily fertilizer injection also show variation, with one reporting 0.88 tons per acre of use annually, another reporting only 0.0005 tons per acre annually (nitrogen and phosphorus only), and the third grower not knowing the use rate. The rates of irrigation reported are not likely to create sufficient runoff to contaminate groundwater supplies with excess

nutrients and the rates of fertilizer use do not seem high enough to create a contamination problem even if there were much higher levels of runoff (Erlewine, 1993). However, since SFWD is not currently monitoring the water quality of the groundwater or surface runoff during storm events, it is not actually known if the nurseries are impacting the water quality of Alameda Creek or the groundwater with the fertilizers.

Pesticides are utilized at all of the nurseries. Present pesticide rules and regulations require the storage of all these products in leak proof containers inside locked storage areas. Table 7-2 contains a list of the herbicides, insecticides, and fungicides used regularly and on an as-needed basis. Again, without monitoring the water quality of receiving water bodies, it is not known if the nurseries are impacting Alameda Creek or the groundwater with pesticides. However, because the majority of lands are being irrigated using drip irrigation, this suggests that the drainage of these chemicals may be limited.

All eight nurseries submit reports to the Alameda County Agriculture Commission. Most of the chemicals used by the nurseries are fairly benign and have half-lives on the order of 7 to 14 days (Lee, 1993). The chemicals of most concern are the ones that have been identified in the California Code of Regulations, Title 3, Section 6800 as chemicals known to have the potential to leach to groundwater. Diazinon is identified as a chemical having the potential to pollute groundwater. Additional monitoring is recommended.

Quarries

The SFWD leases land to Mission Valley Rock Company (234 acres) and RMC Lonestar (280 acres) for quarries along the Alameda Creek in Sunol Valley. There are four active surface mining permits in this area, operated by the two companies, and one permit that has been obtained but has not yet been activated (located between the Sunol Temple and I-680). These existing and planned quarry sites are located in Figure 7-1. The quarries are expected to be active well into the 21st century. The terms of the quarry leases do allow for revisions to prescribe land use and management practices. The Watershed Management Plan, under development, will provide SFWD with guidance for developing lease clauses for prescribing land use or management practices to reflect the policies of the Plan. The Sunol Valley Resource Management Plan, being developed as a part of the Watershed Management Plan, will provide additional detail regarding the current and recommended land use practices of the quarry operations.

TABLE 7-2

PESTICIDE USAGE AT SUNOL VALLEY NURSERIES

Used on a Regular Basis	
Herbicides	**Insecticides**
Ronstar	Diazinon
Roundup	Diazinon 4E
Simazine	Diazinon 50W
Scotts Co. Weedgrass Control	Malathion
	Orthene
	Orthene TT&O
Fungicides	
Bayleton	
Daconil 2787	
Subdue 2E	
Kocide 101	

Used on an As-Needed Basis	
Herbicides	**Insecticides**
Amine-4 24D	Avid
Banvel	Dursban 2E
Diquat H/A	Lindane
Scott Ornamental Herbicide II	Malathion 25
Rohm & Haas Goal	Mavrik
Surflan AS	Sevin
	Sevimol
	Volck oil
Fungicides	**Bactericide**
Fungo Flo	Agristrep
Benlate	
Captan 50 WP	**Miticide**
Cleary's 3336	Pentac Aquaflow
Dithan M-22	
Plantvax-75W	**Mulluskicide**
Terraclor	Metaldehyde
Triforene	Psce Intel Deadline granules
Chipco26019	
Fore	

Source: SFWD, 1993

The potential contaminants associated with quarry activities are from surface runoff containing oil and grease from trucks (as discussed under Automobile Corridors), spilled or leaking fuel tanks, and sediment loadings to Alameda Creek. Mission Valley Rock and Lonestar both have Regional Water Quality Control Board permits or files as required for their operations. These quarry operators meet the discharge conditions of the permits.

Compacted or paved areas are provided for parking, storage of materials, and truck access roads. The quarries have above ground fuel tanks, provided with secondary containment. There have been several significant incidents at the Lonestar facilities of spilled, vandalized, and released fuel and other petroleum products at the quarries. There have not been any recorded incidents at the Mission Valley Rock facilities. Runoff from paved and compacted areas generally drains into the quarry pits except during unusually high rainfall.

Aggregate is usually excavated together with silt and groundwater. Siltation ponds are used to separate out the silt and groundwater. The silt settles into the bottom of the pond, the groundwater percolates back into the soil, and the aggregate is removed. The ponds are used until they fill with silt. The actual quarry operations are separated from Alameda Creek on level ground. Discharges to Alameda Creek are limited to periods when rainfall exceeds the holding capacity of the sedimentation ponds at the quarries; these occasional discharges are permitted by the Regional Water Quality Control Board. Monitoring of total dissolved solids (TDS) is required under these permits (Jensen, 1994).

Alameda County inspects the quarries annually; there have been no major permit violations. Some minor violations have been noted, but they were promptly corrected. According to recent investigations conducted for SFWD on the groundwater and aggregate resources in Sunol Valley, water quality of the groundwater aquifer does not appear to be impacted by quarry operations. It is not known if water quality in Alameda Creek is impacted because water quality monitoring is not conducted. A recent concern has surfaced regarding the use of completed quarries adjacent to SFWD lands as disposal pits for other materials such as treatment plant backwash sludge by ACWD. This should be investigated and discontinued if any leaching into ground or surface waters is occurring.

In the future, after the quarry resources are exhausted, the sites will be restored as specified under reclamation requirements for each permit. All equipment is required to be removed, unless SFWD requests that some structures be left in place. A vegetative screen will be planted for

visual reasons and grasses will be planted to minimize erosion. SFWD is currently studying the possibility of utilizing the aggregate pits for water storage.

Industrial Activities

The Quantec and Calaveras Test sites, recently removed from the southern end of the Calaveras Reservoir, were used for several decades by an explosives research and manufacturing facility and an aerospace and electronic tracking facility. Contaminants may have been left from the manufacturing and testing operations after these operations ceased. Underground fuel tanks are present on the site. Some herbicides were sprayed for weed control. Burn pits used on the site may be points of contamination containing a number of chemicals or heavy metals.

Study of the site is complicated because Quantec, as a part of its closure plan, is only working on characterizing the part of the site under its control. It is possible that other areas of contamination outside of Quantec activities may be present.

The potential for an impact to the Calaveras Reservoir exists. Because of the old disposal practices described above, the groundwater may be contaminated and this could convey the contaminants directly into the Calaveras Reservoir. However, the extent of impact is not known at this point. Investigations, including hydropunch sampling, are currently underway. The preliminary investigation found that there was little historical information on the materials that may have been used or disposed of at the site and the dates of operation of the facility have not been accurately determined. An estimate of the potential for this site to impact the reservoir should be made after the site investigations are completed.

Outside of the study area is another industrial land use, the General Electric Vallecitos Laboratory. This facility is located off of Highway 84 along Vallecitos Creek which drains into Alameda Creek near the SFWD Sunol headquarters. It conducts nuclear fuel research and produces radio-isotopes for medical and other uses. According to the wastewater discharge permit, the sanitary waste is treated and then held in a retention basin until it is used for spray irrigation on the property. The industrial wastewater consists of non-contacting cooling water and nonradioactive wastewater from various research labs at the facility. It is pH adjusted, tested for compliance with effluent limits, and then stored in a retention pond for release as batch discharges into Vallecitos Creek.

Natural Resource Management

Several key natural resources within the watershed which are managed by SFWD and land owners include those listed below. In addition, a brief discussion is provided on atmospheric contamination.

- Fire management practices
- Star thistle control
- Ground squirrel control
- Control of particulates and asbestos fibers

Fire Management. SFWD actively manages the Alameda watershed lands to reduce the fire hazard. Cattle grazing leases are managed over a large portion of the watershed which reduces fuel loads, and SFWD uses mechanical means of fuels reduction. A small tractor with a rotary mower attachment and a larger tractor with a flail mower is used to create fuel (fire) breaks in the watershed. Some discing is performed along roadsides in high use areas where fire danger is highest and there are historical fire problems, but discing is kept to a minimum because of erosion concerns. Discing is performed along approximately 10 miles of Highway 84 and Calaveras Road. During the drought more discing was performed because of reduced cattle grazing in the watershed. Prior to each fire season, the access roads in the watershed are regraded so that they can be used as fire breaks.

Fire management practices can increase the amount of erosion in the watershed through the improper placement and management of fire roads. However, fire management practices typically decrease the potential for water quality contaminants in the receiving water bodies by decreasing the likelihood of a wild fire. Grazing may serve to decrease the likelihood of a wild fire by reducing the volume of fuel available

A fire would result in a loss of vegetation, which would expose the soil to the direct impact of raindrops, which then reduces the infiltration capacity and increases runoff. With the loss of vegetation rainfall does not collect and runoff along established depressions, but is dissipated rapidly as sheet flow. Another condition that would contribute to increased erosion is the production of hydrophobic soils. Hydrophobic soils are a particular product of fires in chaparral vegetation which result in a decreased permeability of the soils and an increase in runoff. The increased erosion that would follow a wild fire is one of the greatest potential contaminant

sources in the Alameda watershed. The sediment impacts are discussed below under particulates.

Star Thistle Control. The Alameda County Agriculture Commissioner is administering herbicides to control the growth of purple star thistle and Iberian star thistle in the watershed. Between June 1992 and June 1993, Alameda County used 241 ounces of the herbicide Rodeo, 1,721 ounces of Dacamie 4D, and 60 ounces of Roundup to control the populations of the star thistles. Rodeo is considered safe for use in the vicinity of water sources and is reported to be non-toxic to aquatic life (Deasy, 1994).

Ground Squirrel Control. The Alameda County Agriculture Commissioner assists ranchers in controlling populations of ground squirrels that compete with cattle for grains and undermine the soils by burrowing activity. Ranchers are provided with supplies of an anti-coagulant squirrel poison. The two anti-coagulants used in the watershed are chlorophanicone and diphanicone; these chemicals are used in 0.01 percent concentrations in the squirrel bait. In 1993, approximately 1,000 pounds of diphanicone were used over approximately 3,000 acres. Chlorophanicone was not used as part of the Alameda County program in 1993 (Gouvaia, 1994). The rancher using the most squirrel poison in 1993 has leases in the San Antonio Reservoir watershed and upstream of the Sunol infiltration galleries.

Ranchers are required to find evidence of squirrel activities before using the poison. The poison is provided mixed with grain and distributed in areas where squirrels are known to be feeding. The squirrels must eat the poisoned grain for five to eight days before massive internal hemorrhaging occurs. An estimated 90 to 95 percent of the poisoned grain is consumed by the squirrels. Poison that is not consumed breaks down in two to three weeks (Gouvaia, 1994). Not enough is known about the subsequent impacts of the poison to the watershed waters after the squirrels have died or are eaten by other animals.

Control of Particulates and Asbestos Fibers. The Alameda watershed lies within a geomorphic province prone to earthquakes and landslides. In addition to landslides, and natural processes, many of the soils in this watershed erode easily due to construction activities and an increase in impervious surfaces. The deposition of sediments can clog stream channels and reduce the capacity of the reservoirs. This WSS is, however, focused on the water quality impacts of erosion. The primary water quality concerns are that sediment is a major carrier and catalyst for pesticides, organic residues, nutrients, and pathogenic organisms. The increase in turbidity at the treatment plant from the fine particles which have not settled to the bottom of

waterways during transport results in increased treatment operations (e.g. more backwashing of filters, higher disinfectant dosages), increased likelihood of THMs and other disinfectant byproducts being generated, and a greater level of risk of pathogens slipping through the treatment process.

For the watershed management plan SFWD is currently developing, Montgomery Watson analyzed the watershed's physical characteristics to identify zones which are more vulnerable to increasing particulate loadings to the water bodies. The analysis utilized GIS soils, slope, vegetation, and water body proximity data. Soils which have a low dry density (clays) were identified because they are lighter and more likely to be carried from streams to the treatment facilities. The lands were grouped by the steepness of slopes. Vegetation communities which provided the least amount of protective cover from rainfall were also identified as having a high vulnerability. And all water bodies within the watershed were mapped and a boundary of vulnerability identified. The GIS layers were then composited to correlate each of these physical characteristics and the results indicate the lands most vulnerable to particulates loadings. As presented in Figure 7-2, the majority of Alameda watershed lands are of high or moderate vulnerability to particulates loadings. Appendix D provides a thorough discussion of the methodology of this analysis and includes a copy of the map reflecting the composite parameters. This analysis focused on fine particles which impact the water treatment process verses sands and gravels which may dislodge more easily but are heavy and settle out quicker.

The watershed also contains serpentine parent material on the upper slopes north of the Alameda Creek. Serpentine is a source of asbestos fibers, most of which must be filtered out of the water through the treatment process, as discussed in Section Five, Analysis of Alameda Watershed Water Quality Conditions. Care should be taken by SFWD to avoid or minimize construction of roads or other facilities in areas of serpentine materials.

Atmospheric Contamination. Dry deposition, acid rain, and acid fog have the potential to provide significant impacts in the future to SFWD lands and waterbodies that are otherwise well protected. Air contaminants from urban areas may be deposited in the Alameda watershed and subsequently impact the quality of waters produced or stored. Although air contaminants may directly affect surface waters, the more likely potential impact is through a change in soil pH caused by acidic deposition. Exchange processes in the soil may buffer the acidic deposition for extended periods, however, at some point the soil pH may shift with a resultant increased mobilization of metals with public health significance. Acidic deposition can take the form of

acid rain, acid fog, and dry deposition. The California Acid Deposition Monitoring Program (CADMP) findings are summarized below.

- Nitric acid is a major part of both wet and dry deposition
- Acid fog can be up to 100 times more acidic than rain
- A variety of human-made materials are damaged by acidic pollutants
- Rates of acidic deposition differ widely within the state (most of the work has focused on the Sierra Nevada and surface water impacts)

The impact to the SFWD watersheds from acid deposition is unknown at this time. Data are being gathered by the California Air Resources Board's Atmospheric Acidity Protection Program may help provide quantitative information on the amounts of acidic deposition in the SFWD watersheds. This information, together with information on soil types, can be assessed to identify more precisely the potential threat to drinking waters.

CADMP has established several monitoring stations throughout the state including one in Fremont. It may be possible to extrapolate from the Fremont data to estimate the acidic deposition within the Alameda watershed in the future. The Air Board has also completed soil sensitivity surveys throughout the Sierra. Similar methods could be used in conjunction with the SFWD GIS mapped soils data.

SFWD Operations

Watershed lands are patrolled by watershed keepers who live in cottages located within the watersheds; cottage locations are provided under the section describing Sanitary Facilities. SFWD also maintains boats on the two reservoirs for use by the watershed keepers in patrolling and maintaining the reservoirs. In addition to the regular watershed patrol activities, maintenance and/or construction activities must occasionally be performed on the watershed lands. SFWD also operates the water treatment plant adjacent to Alameda Creek and an operations and maintenance yard in the Sunol Valley called the Sunol headquarters.

Watershed Keeper Cottages. Potential contaminants at the cottages originate from household trash and septic systems (discussed above), general maintenance activities, increased usage of roads to and from the cottages, and above ground heating-fuel tanks. Each of the watershed keepers has a pickup truck equipped with a small fire pumper unit that is used as a patrol and maintenance vehicle. Trash generated at the cottages is collected in garbage cans. The

watershed keepers use the pickup trucks to transport the cans to a dumpster in the Sunol service yard at the Sunol headquarters. The two cottages at the Calaveras Dam and the cottage at the Alameda East Portal are heated with liquid propane that is stored in above ground tanks. The cottage at Turner Dam uses electric heat.

There is some use of herbicides around the cottages. Ronstar is applied every three to four months; this chemical is a dry granular compound that is used to prevent week seeds from germinating. Ronstar has an active life of two to four months and apparently leaves no residual. Weeds are also controlled with Roundup, a non-selective herbicide that is used to control weeds when they are between one and three inches high. Roundup has recently been replaced with Rodeo, which is a less toxic herbicide that is safe for use near water sources. All uses of pesticides are approved by the Alameda County Agricultural Commission (Deasy, 1994). In addition to the cottages, herbicides are used at the filter plant and the San Antonio Pump Station. Vegetation around the cottages is also controlled using a small tractor, which is stored and fueled at the Sunol yard.

Boats. There are several SFWD boats in the Alameda watershed. A small boat is located at each of the reservoirs and a newer, larger one is used on Calaveras Reservoir. A pontoon boat is also available and is used for applying copper sulfate. The two small boats are fueled with five-gallon, removable fuel tanks. A permanently mounted fuel tank is used in the larger boat; fuel is carried to this boat in five-gallon tanks. The fuel tanks are filled at the Sunol yard on an as-needed basis. Although fuel spills from boats have high water quality impacts because the fuels would go directly into the reservoir, the tanks are not of significant size. Since most fuel transfers occur at the Sunol yard, the potential for spilling into the reservoirs during fueling is eliminated.

Treatment Operations. The Sunol Filter Plant is located near Calaveras Road next to Alameda Creek; the facilities are described in Section Two. The potential contaminants which could be released into Alameda Creek from WTP operations or parking lots include chlorine, sodium hypochlorite, potassium permanganate, oil and grease, PCBs, and stormwater runoff. Backwash and sludge, which could contain microorganisms, are stored in sludge facilities which are contained but are reaching capacity. Sludge disposal options are being considered at this time and include new sites as well as the reuse of the current site. Weeds are controlled at the WTP using Ronstar and Rodeo. The primary impact from the WTP is from stormwater runoff or accidental plant operations runoff carrying contaminants that have spilled, leaked, or been dumped on the grounds and are then discharged into Alameda Creek. Spills of chemicals such as

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potassium permanganate, though rare and of lower cumulative volume than from stormwater runoff, can cause acute toxicity to aquatic life in Alameda Creek. An unusual spill of water treatment chemicals would likely not impact Alameda Creek from a drinking water supply perspective since these waters can be picked up downstream at the Filter Galleries and sent back through the WTP where the dosages of treatment chemicals could be adjusted. Rather, a spill could result in significant impacts to wildlife and vegetation along the riparian corridor.

Miscellaneous. The Sunol maintenance yard, at the Sunol headquarters, contains above and below ground fuel storage tanks. In addition to possible leaks or overfills at the tanks, maintenance activities can generate potential contaminants. Pollutants may be released via fueling, fluid removal and replacement, washing, leaks, and spills. Specific pollutants generated by vehicles are discussed under Automobile Corridors. The yard naturally drains into Alameda Creek.

SFWD anticipates using approximately two pounds of anti-coagulant poisoned grain to control the ground squirrel population along Temple Drive. Ground squirrel control is discussed under natural resource management, above.

PROJECTED CHANGES IN SOURCES OF POTENTIAL CONTAMINANTS

Included in Figure 7-1 are lands within the watershed which are planned to change to another use. For example, the industrial activities at the south shore of Calaveras Reservoir have recently been closed down, and the lands next to the Sunol water temple and headquarters are permitted for future quarry activities.

Privately owned land along Apperson Ridge, which drains to the San Antonio Reservoir, is designated by Alameda County's Draft East County Area Plan for aggregate resource development and part of the land is already permitted by the County. The owners of the permitted lands are not expecting to utilize the basalt site until the Sunol Valley gravel resources are exhausted. The permit is valid until at least year 2060 and can be renewed. An access easement has been provided by SFWD along the south end of San Antonio Reservoir. The quarry is projected to generate about 1,000 vehicle trips per day when it opens. If management controls are not placed on the quarry activities, the risk of contamination from particulates increases. Also, impacts related to truck traffic, discussed previously, will increase.

At the east side of the watershed are lands, including the "Grimmer" property, designated by the Santa Clara County and Alameda County General Plans for land uses which may increase the number of residents. The development of these lands will increase the risk of contamination in addition to general residential development within the watershed because it will essentially open up the eastern watershed to the public. The remaining lands within Santa Clara County are designated for Resource Conservation Area, Hillsides, Existing Regional Parks, and small amounts of land designated for Rural Residential.

Alternatives within Alameda County's draft East County Area Plan designate watershed lands for water management/protected open space within SFWD lands which may beneficially impact the watershed. However, aggregate resources are being protected along Apperson Ridge for future quarry activities. Interstate 680 is projected to increase in average vehicle trips per day from 97,000 to 127,700 by year 2010. The segment of I-680 through the watershed is planned for expansion to eight lanes in the future. Vallecitos Road from Sunol to Livermore is expected to increase in volume under the preferred alternative from 11,000 average vehicle trips per day to 58,300 by year 2010. This highway is also planned for expansion from two lanes to six, in the future.

A new petroleum pipeline, called the Mojave Pipeline, which would cross the Sunol Valley immediately adjacent to the SFWD Sunol Headquarters is being considered by the Federal Energy Regulatory Commission. This pipeline would be located near the Filter Galleries.

SIGNIFICANCE OF POTENTIAL CONTAMINANT SOURCES

The area where the Quantec and Calaveras Test Site facilities were located is the most significant potential contaminant concern. The extent of contamination is under investigation by SFWD as well as its impact to Calaveras Reservoir water quality.

The land uses and activities closest to the reservoirs and reservoir tributaries are of more concern than uses downstream of the reservoirs which drain to the Filter Galleries. This is because the Filter Galleries produce a smaller quantity of supply, provide limited storage, and can be temporarily removed from the system easily. However, a gradual degradation of water quality contributing to the Filter Galleries should not occur because it is a source of supply for the city and should be maintained.

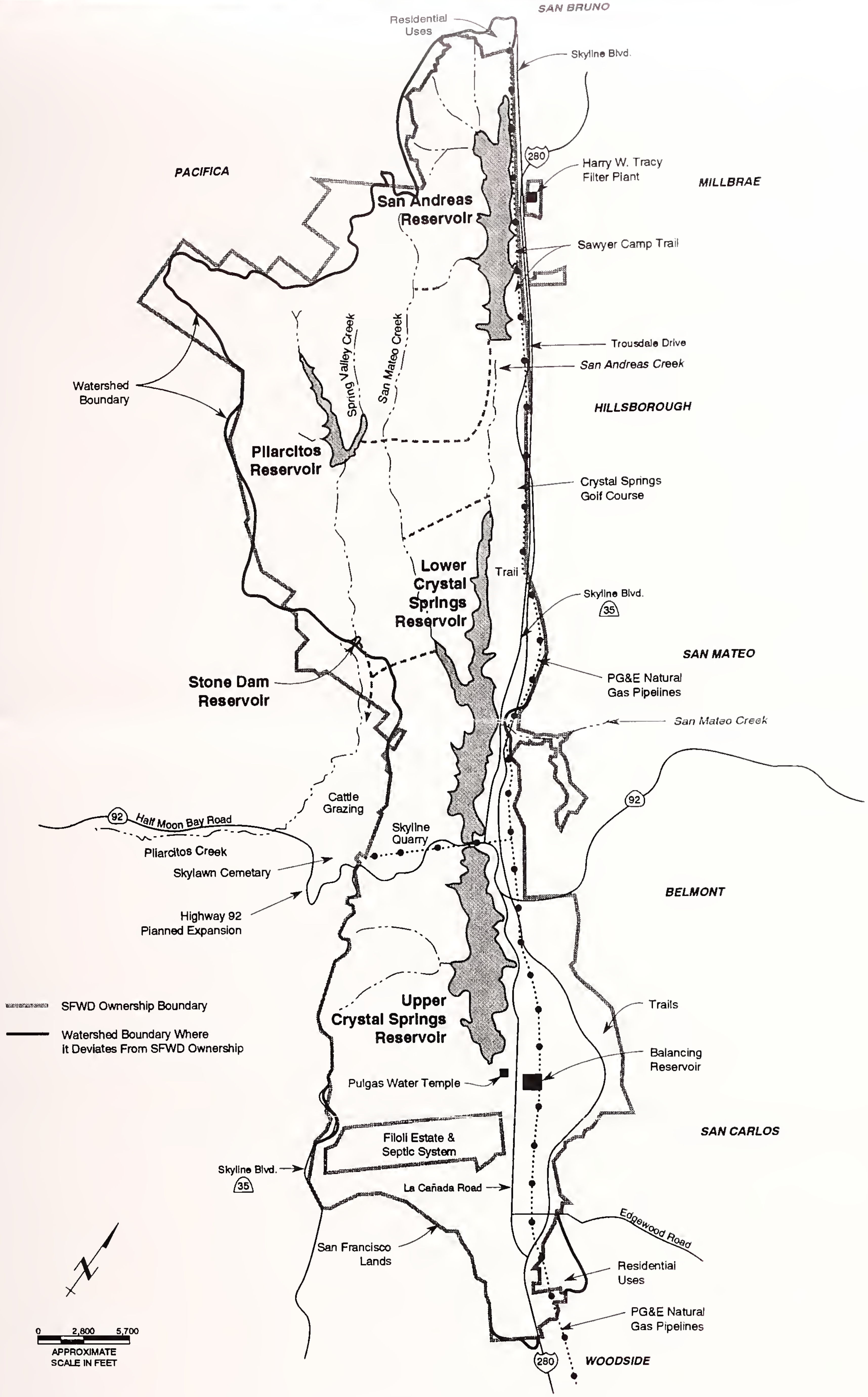
The risks to water quality associated with Calaveras Road and other public roads near the reservoir are considered significant because of the increased likelihood of accidental spills, increased runoff, vandalism, and fire. The recreational areas managed by EBRPD also increase the risk of fire within the watershed. Fire related sedimentation impacts are considered significant in the Alameda watershed.

If ruptured, the Chevron pipeline could cause a significant impact to San Antonio Reservoir depending on the location of the rupture and the extent of the spill, however, ruptures are rare occurrences; the significance of this potential contaminant source will decrease when the pipeline is realigned. However, the proposed Mojave pipeline should be discouraged due to its proximity to the Filter Galleries.

The pathogens associated with wildlife and livestock are considered very significant because its treatability is uncertain and information on the sources (other than cattle) within the Alameda watershed is limited. Finally, the sedimentation, nutrients, and organics associated with the high clay content of the watershed soils are a significant source of contamination to the receiving reservoirs. Land disturbance activities should be closely monitored and proper construction practices required to minimize the impact.

The future rural residential development which could occur both within the reservoir watershed and adjacent to it has the potential to impact the reservoirs. As the septic systems age, there is a greater likelihood of system failures, and as the adjacent lands develop, there will be an increased usage of the public roads, thus leading to a greater risk of accidental spills, increased runoff, fire, and vandalism. The planned quarry activities above San Antonio Reservoir pose a significant threat to the water quality from sedimentation conveyed through the tributaries and from the increased road runoff and risk of truck accidents.

The significance of the quarries and nurseries downstream of the reservoirs can be determined if water quality data were obtained specifically for this purpose. A monitoring program should be developed and implemented to assess the water quality of the runoff. Further investigation of disposal materials being placed into adjacent quarries is needed. I-680, Highway 84, and the railroad tracks pose a significant risk to water quality at the Filter Galleries due to accidental spills and runoff. The significance of the highways will increase in the future as these roads are more heavily used.



LAND USES WITHIN PENINSULA WATERSHED

FIGURE 8-1

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MONTGOMERY WATSON

Transportation Corridors

Within the watershed there are 53 miles of highway and ramps, 48 miles of paved roads and streets, 36 miles of unpaved roads, and 25 miles of trails. The major state highways to pass through the watershed are Interstate 280 and Highway 92. I-280 runs along the eastern border of the watershed. Highway 92 crosses Upper Crystal Springs Dam, bisecting the Peninsula watershed; the planned expansion of Highway 92 is discussed under projected changes at the end of this chapter. Canada Road and Skyline Boulevard cross portions of the east side of the Peninsula watershed. The unpaved access roads in the watershed are used by the watershed keepers to patrol the watershed and they serve as fire trails and some as equestrian trails.

A very small area (less than three acres) of Skylawn Cemetery near the intersection of Highways 92 and 35 is within the watershed. A cemetery road and the three acres drain directly to a tributary of Upper Crystal Springs Reservoir.

Concerns related to these transportation corridors include 1) road surface runoff of copper, lead, zinc, oil and grease, and polycyclic aromatic hydrocarbons from leaks, spills, brake pads, and other general automobile usage, 2) fire danger as a result of auto accidents, parking on road shoulders, and un/intentional ignition from thrown cigarettes, matches, etc., 3) herbicides applied during roadside maintenance, 4) illegal dumping and trespassing, and 5) rapid runoff and increased erosion due to poor road design and maintenance practices.

In addition, during severe north-east winds. airplanes at the San Francisco Airport utilize a different landing and takeoff pattern than under normal wind conditions. During the severe north-east winds, the airplanes pass approximately 500 feet directly over Crystal Springs Reservoir. It is not known to what extent the watershed lands and waterbodies are receiving atmospheric contaminants associated with the airplanes.

Surface Runoff. In 1992 an average of 90,000 vehicles per day used I-280 in the area of the I-280 and Highway 92 interchange. Runoff from I-280 is captured as part of a separate stormwater collection system and is conveyed out of the watershed. In 1992 an average of 23,600 vehicles per day used Highway 92 (Cambron, 1994). Highway 92 drainage is not removed from the watershed. A hazardous material spill along Highway 92 could be significant because of the likelihood that contaminants would flow directly into the reservoir. Even if vehicles are not transporting hazardous materials, accidents may result in gasoline and engine coolant spills.

There are risks of contamination associated with the separate stormwater collection system during emergency overflow conditions; however, this is an unusual occurrence according to Caltrans. The worst case scenario would be a tank truck loaded with hazardous waste or a hazardous material spilling directly into the surface waters of the Crystal Springs Reservoir. This is most likely to occur along Highway 92 as it crosses the dam. It is unlikely that a direct cleanup of a spill would be possible once it entered the surface water. Depending on the toxicity of the substance spilled, the ability of the SFWD to use the reservoir water and the storage availability for Hetch Hetchy water will be impacted for some period of time.

Fire Risk. Fire created by activities along the roadside, (particularly along I-280 and Highway 92 due to the high traffic volumes), could have significant impacts on the reservoir water quality, as described in Section Seven. The risk of fire in the Peninsula watershed is great due to the lack of recent fires and the build up of fuels. This is discussed more later under natural resources management.

Herbicides. The maintenance of vegetation along the shoulder of Canada Road and Skyline Boulevard is performed with mowers and a limited amount of Roundup defoliant. No other information is available on the maintenance of vegetation along roadways.

Dumping. Illegal dumping and trespassing may impact reservoir water quality by introducing contaminants from materials dropped into creeks leading to the reservoirs. The illegal dumping of household wastes and appliances, and occasionally a human body, does occur within the Peninsula watershed and is likely to increase as the Bay Area population continues to increase.

Erosion. The potential water quality impact of the access roads is predominantly through the production of sediment due to rapid runoff and subsequent erosion. Also, the roads must be maintained properly or else they will expose material to erosion and will provide collection points that allow runoff to collect into larger more erosive flows. No specific estimates are available on the amount of sediment being produced per mile of roadway; the amount of sediment will vary according to the steepness of the grade, soil type, usage, maintained condition, and the original design. All construction, including general maintenance activities, in the watershed should follow strict erosion control practices. Road regrading practices have been recently modified and standardized. Annual road regrading is no longer a requirement in the Peninsula watershed, and new grading procedures reduce the need for culverts.

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Caltrans is currently planning for the expansion of the Highway 92 because collisions occur at a rate 30 times higher than the statewide average for similar roads (Chronicle, 1993). It expects the Highway 92 volume of traffic to increase to 28,700 vehicles daily by 1995. CalTrans has determined that an environmental impact report is not needed for the project, so specific potential impacts are not known.

Utility Corridors

Two PG&E natural gas pipelines (Line 109 and Line 132) cross portions of the eastern edge of the Peninsula watershed. South of a valve box near the northeastern corner of the SFWD lands, the pipelines run parallel to each other, along a route that runs contiguous to or through the watershed. These lines were installed between 1929 and 1947, but portions have been replaced between 1960 and 1990 in conjunction with the construction of I-280 and other new development. Line 109 varies between 22 inches and 30 inches in diameter and operates with a maximum pressure of 375 pounds per square inch gage (psig). Line 132 is 30 inches in diameter and operates with a maximum pressure of 390 psig. The valve box is fenced (PG&E, 1993).

A third natural gas pipeline, the Half Moon Bay feeder main, crosses the Peninsula watershed from east to west and can be supplied by either Line 109 or Line 132. This pipeline runs along Highway 92 and crosses Upper Crystal Springs Dam. The diameter of the pipeline varies between 8 and 12 inches. The maximum operating pressure is 400 psig and the normal operating pressure is 375 psig (Day, 1994).

A rupture of the high pressure gas lines would result in blow out and rapid erosion of surrounding soils. Combined with rain, the rapid erosion could cause increased sedimentation in the reservoirs. Condensate (heavier petroleum hydrocarbons) from the pipe might cause some additional contamination. If the rupture occurred during dry weather, it might result in a fire in the watershed which would in turn make the impacted area susceptible to significant erosion.

PG&E plans to replace segments of Lines 109 and 132 that run north of the valve box on the eastern edge of the SFWD lands near the intersection of Skyline Drive and Ridgeway Avenue in the City of San Bruno. The project will also require moving the valve lot 800 feet to the south. The replacement segments will be routed to avoid crossing the San Andreas Fault. The current route of each pipeline crosses the fault twice, outside of SFWD lands. The proposed new routes lie outside of SFWD lands, but within the watershed boundary (PG&E, 1993).

Recreation and Research

Recreation related activities in the Peninsula watershed are available to the public. Heavy use activities are limited to a recreational easement east of the Crystal Springs and San Andreas Reservoirs and west of I-280. Access within the remaining watershed lands is limited to permitted organized equestrian groups and educational study groups. The watershed is closed to the public during times of high fire risk.

The recreational easement allows for limited types of uses such as trails located parallel to I-280, and picnicking at the Pulgas Water Temple. Activities in this easement include walking, bird watching, bicycling, photography, jogging, and picnicking. The public trails are heavily used; approximately 200,000 visitors per year use the Sawyer Camp Trail. Public usage of the Pulgas Water Temple is low at this time because parking is limited; parking was restricted recently because extensive policing and maintenance was required due to vandalism at the facilities. Some water temple visitors ride bicycles on Canada Road or walk up from Filoli Estate. Weddings and other permitted activities also occur at the temple; parking is available for special events.

Permitted access is controlled by the Watershed Management Group of SFWD. Members of equestrian groups are required to undergo a security check before receiving an individual permit. Watershed keepers report that equestrian users are responsible and respectful and actually help the keepers patrol the watershed. There are presently 40 equestrians who obtain permits from SFWD.

Groups requesting permits must be incorporated and the group must have general liability insurance coverage of $1,000,000 for members for the day of the permit. Permits are issued for one day's use and require that the groups be limited to 10 to 25 people. A maximum of three permits per year per group is granted. About 100 permits a year are issued. Even though there are occasional violations of permit requirements, most of the groups provide some sort of benefit to SFWD. For example, the Audubon Society provides estimates of the bird populations in the watershed.

The activities that are potential sources of contamination include hiking and cycling off of the designated trails which causes erosion, improperly placed trash, vandalism, increased risk of fire, and microorganisms associated with human, pet, and horse wastes. Contaminants could be deposited by vandals in the Pulgas Water Temple which would impact Crystal Springs

Reservoir. In addition, the past use of a U.S. Geologic Survey boat on San Andreas probably resulted in the introduction of an undesirable and noxious water plant that is choking out other vegetation in parts of San Andreas Reservoir. Garbage cans are located in high use areas and are collected by the watershed keepers and emptied at the Millbrae facility.

Crystal Springs Golf Course

The Crystal Springs Golf Course management leases 70 acres of SFWD land near the community of Hillsborough on the eastern edge of the Peninsula watershed. A general discussion of golf course management and potential contaminant sources, including fertilizers, pesticides, and vehicle related pollutants is provided in Section Seven with the description of the Sunol Valley Golf Course. Site specific information, other than the 1993 use of products presented in Table 8-1 below, is not available for the golf course; data should be collected and reviewed to determine the potential for contamination. The terms of the Crystal Springs golf course lease do allow for revisions to land use and landscape management practices. With the next renewal, SFWD will require monitoring of particular water quality parameters. The Watershed Management Plan, under development, will provide SFWD with guidance for developing lease clauses for prescribing land use or management practices to reflect the policies of the Plan.

TABLE 8-1

PESTICIDE USAGE AT CRYSTAL SPRINGS GOLF COURSE

	Name	Quantity
Herbicides		
	Gordons Trimec	36.5 gallons
	Sandoz Banvel	4.2 gallons
Fungicides		
	Scotts Fungicide X	318 pounds
	Scotts Fluid Fung	12 quarts
	Mobay Bayleton	33 pounds
Miscellaneous		
	Pestcon Fumitoxin	7.8 pounds
	Scotts FF II	250 pounds

Source: SFWD, 1993.

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Filoli Estate

The Filoli Estate, a 657-acre parcel owned and operated by a private foundation, is located south of Crystal Springs Reservoir. In addition to the potential contaminants associated with automobiles, access roads, and a parking area, as discussed under Transportation Corridors, and the septic system discussed under Sanitary Facilities, Filoli also has maintenance activities associated with the famous gardens as well as structures and an apple orchard. There are above ground and buried storage tanks containing diesel fuel and gasoline at the site. Because of the proximity of Filoli to Crystal Springs Reservoir, more information is needed regarding the condition of these tanks.

The Filoli gardeners keep good records of the application date, material, amount, and concentration used, and the location of usage for all pesticides, herbicides, and fungicides. The amount used is rather small and the gardeners have been making a concerted effort to phase out the use of products such as Orthene and substitute the least toxic alternatives. The pesticides listed in Table 8-2 were used at the Filoli Estate between January and August 1993. According to SFWD, pesticides and herbicides have not been detected in Crystal Springs and San Andreas Reservoirs.

Sanitary Facilities

There are numerous sewage facilities located at the watershed cottages and at recreational sites. There is are two septic systems at the Filoli Estate.

Sewage Facilities. Ten watershed keeper cottages are located within the watershed: North San Andreas, Davis Tunnel, Pilarcitos, San Andreas, Cypress, Sawyer Camp, Lower Crystal Springs, Upper Crystal Springs, and Canada. Toilets at the watershed keeper cottages are connected to concrete sewer vaults. Most of the vaults have capacities of approximately 7,500 gallons. None of the cottages have septic systems and leach fields. The vaults are pumped once per week by a SFWD waste tanker. Some high use vaults are pumped two to three times per week.

Sanitation facilities (eight chemical toilets and two flush toilets with tanks) for recreational users are provided on the major trails used by the public, equestrian users, and permitted groups. The Pulgas Water Temple area has two chemical toilets. The holding tanks are pumped out weekly by the SFWD waste tanker.

TABLE 8-2

PESTICIDE USAGE AT FILOLI ESTATE

	Name	Quantity
Molluskicide		
	Metaldehyde Slug Bait	17 cups, 1 ounce
	Metaldehyde 7.5G	2.75 pounds, 1/4 cup
Insecticide		
	Mavrik	11 ounces, 2 Tbs, 43 tsp
	Safer's Insecticidal Soap	1 pint premixed bottle
Fungicide		
	Funginex	2 pints, 342 ounces
Miscellaneous		
	Enstar 5-E	2 ounces, 3 Tbs, 58 tsp
	Greenshield	5 ounces, 90 Tbs
	Dormant Spray Oil	2 gallons, 1 quart
	Lilly Miller Superior Oil	3.5 gallons
	Sat-T-Side Oil	2.5 gallons, 50 Tbs, 2 tsp
	Sun Spray Oil	2.5 gallons, 24 ounces, 31.5 Tbs

Septic System. The septic systems at Filoli Estates spread into leach fields that should allow microbial degradation of the biological contaminants before reaching the Crystal Springs Reservoir. Monitoring is not conducted; this information is needed to assess any impacts.

Residential Areas

Residential development has taken place on several privately owned parcels along the eastern edge of the watershed between Highway 92 and the City of San Bruno. Several private residential parcels are also within the watershed in the City of San Bruno at the north end of the watershed. Since the sewage is municipally collected and treated out of the watershed, the only concerns associated with these land uses are household use of hazardous materials and fertilizers, herbicides, and pesticides, and oil and grease from automobiles.

Residential areas adjacent to SFWD lands also increases the risk of fire. In addition to these small parcels within the watershed, three sides of the watershed are bordered by urban residential land uses, thus significantly increasing the risk of fire to watershed lands.

[illegible]

Wildlife and Livestock

As described in detail in Section Seven, wildlife and livestock have the potential to generate nutrients, pass along microorganisms, and increase erosion of sediments. A brief description of the wildlife known or likely to exist is provided below. In addition to the natural wildlife which exists within the watershed, adjacent to the Peninsula watershed is land utilized for cattle grazing and household pets. Although the lands utilized for cattle grazing are outside of the watershed to the west of Crystal Springs Reservoir, the cattle often are found on SFWD lands within the watershed.

The Peninsula watershed provides wildlife habitat for foraging and breeding and serves as a travel corridor and stopover along the Pacific Flyway. The majority of habitat lies west of the reservoirs and ranges from grasslands to mature Douglas fir forest. Since the watershed has not burned for at least 50 years, much of the vegetation is in a climax state but still provides a variety of habitats. Species utilizing these habitats include many raptors, herons, bats, snakes, frogs, and feral pigs. Crystal Springs and San Andreas Reservoirs often become inundated with seagulls. The reservoirs and most streams contain exotic fish such as mosquitofish and largemouth bass as well as natives such as rainbow trout and threespine stickleback originating from those present prior to construction of the reservoirs.

Natural Resource Management

Natural resources within the Peninsula watershed which are managed by SFWD include fire management practices and the control of particulates. In addition, a brief discussion on atmospheric contamination (other than that related to the airport as described under Transportation Corridors at the beginning of this section) is provided in Section Seven.

Fire Management. Fire management practices can increase the amount of erosion in the Peninsula watershed through the improper placement and management of fire roads and fire breaks. However, fire management typically decreases the potential for contamination by decreasing the likelihood of a wild fire. Water quality impacts from fires are discussed in Section Seven. On the SFWD lands, the watershed keeper access roads are used as fire access roads. Some of the fire breaks on Montara Mountain are particularly notable sources of sediment. The last major fire in the Peninsula watershed occurred in the 1940's; the fire burned for six weeks. In 1973 there were 30 fires along Sawyer Camp Trail when it was open to

Water Quality Vulnerability Zones for Particulates

PENINSULA WATERSHED

SAN FRANCISCO WATERSHED MANAGEMENT PLANS

FIGURE 8-2

vehicular traffic; three were of "fair extent". Current fire management practices include some brush control and controlled burning, including annual burning of the face of San Andreas Dam.

Some fuel breaks are made with a machine called a Unimog. The Unimog crushes and mulches brush; this procedure promotes the growth of younger brush, which provides less fuel than the older brush. The Unimog is stored at the Millbrae facility. Fire breaks are also created along the areas where the Peninsula watershed adjoins urban lands. Fire breaks are created by discing 30 to 40 foot-wide areas in open fields along the edge of the SFWD lands. The interface between SFWD lands and urban lands is seven miles long, and includes lands bordering the cities of Millbrae, Burlingame, Woodside, and San Mateo.

Fire control practices are being evaluated on a 100-acre study area that is being managed as a joint project of the SFWD and the California Department of Forestry. The project goal is to manipulate the age class of the brush to create a fire break as younger brush provides less fuel for fires. The study area is located on the north end of the watershed near Portola Ridge, just west of San Andreas Reservoir in the Pilarcitos drainage area. Fire management in the watershed is also being studied as a part of the Watershed Management Plan project.

Control of Particulates and Asbestos Fibers. The Peninsula watershed lies within a geomorphic province prone to earthquakes and landslides. The drinking water quality impacts associated with the erosion and sedimentation of fine particles are discussed in Section Seven. Appendix D contains the results of an analysis of the watershed lands which are vulnerable to increasing particulate loadings to the water bodies. The majority of Peninsula watershed lands are of moderate or high vulnerability to particulates loading as presented in Figure 8-2.

All construction, including general maintenance activities, in the watershed should follow strict erosion control practices. As discussed under Transportation Corridors, road regrading practices have been recently modified and standardized. Annual road regrading is no longer a requirement in the Peninsula watershed, and new grading procedures reduce the need for culverts. Construction problems have occurred on Peninsula lands recently because of a failure to enforce erosion control practices on outside contractors. The construction of the Coastside pipeline from Crystal Springs Reservoir to CCWD facilities resulted in significant erosion problems.

The Peninsula watershed contains serpentine parent material underlying most of the grasslands generally east of the Crystal Springs and San Andreas reservoirs. Serpentine is a source of asbestos fibers, most of which must be filtered out of the water through the treatment process, as

discussed in Section Six, Analysis of Peninsula Watershed Water Quality Conditions. Care should be taken by SFWD to avoid or minimize the disturbance of serpentine rock and overlying soils. Construction of roads or other facilities in areas of serpentine materials should be avoided, if possible.

Other SFWD Operations

Watershed lands are patrolled by watershed keepers who live in cottages located within the watersheds. SFWD also maintains boats on the reservoirs for use by the watershed keepers in patrolling and maintaining the reservoirs. An abandoned quarry within the watershed is currently used as a storage facility by SFWD and has other authorized uses by others. In addition to the regular watershed patrol activities, maintenance and/or construction activities must occasionally be performed on the watershed lands; this is discussed above under natural resource management. SFWD also operates a water treatment plant adjacent to the watershed and a covered water storage facility within the watershed. The general watershed maintenance facilities are located outside of the watershed in Millbrae at the SFWD headquarters.

Cottages. The locations of the ten cottages are described under Sanitary Facilities. Potential contaminants originate from household trash and sanitary facilities, general maintenance activities, increased usage of roads to and from the residences, and above ground fuel tanks. Most of the cottages are located on hillsides downstream of the various dams or in areas of the Peninsula watershed that are not proximate to the reservoirs. There is some use of the herbicide Roundup around the cottages, but this use is infrequent and minimal. Usually vegetation around the cottages is controlled by using a small, 26 horsepower ride-on tractor. The tractor is usually stored in the watershed and is moved from cottage to cottage. Fuel is transported from the Millbrae facility to the tractor in gas cans. Most of the cottages are heated with a combination of wood and liquid propane. The liquid propane is stored in 200-gallon tanks. The cottage at San Andreas Reservoir is heated with electric heat.

Each of the watershed keepers has a pickup truck for use in patrolling the watershed. Trash generated at the cottages is collected in garbage cans and the patrol vehicles are used to transport garbage cans to a dumpster at the Millbrae facility.

Boats. There are several boats in the Peninsula watershed: one in Upper Crystal Springs Reservoir, one in Lower Crystal Springs Reservoir, and one each in San Andreas and Pilarcitos reservoirs. The reservoirs are patrolled by boat at least once a week. The boats are provided

with fuel in marine-type tanks. The tanks are filled at the Millbrae offices of SFWD and carried onto the boats. When the boats are not in use, the tanks are stored at the watershed keeper cottages. Fuel tanks are refilled on an as-needed basis. Since fuel tanks are filled at the Millbrae yard, the potential for fuel spillage while operating the boats is low; however, appropriate procedures to avoid spillage should be in place and followed.

Skyline Quarry. An abandoned quarry near Highway 92 at the west end of the watershed is currently used by SFWD as a "lay down yard" for storing equipment, materials, and junk. The soils exposed by the quarry operations are a source of easily erodable material that may end up in Crystal Springs Reservoir. In addition, the "junk" stored at the old quarry could be a source of contamination as the metals and other materials break down. The site is also used by law enforcement officers for target practice and other activities. Runoff from this area is not monitored and is difficult to estimate its impact to waterbodies.

Miscellaneous. The herbicide Roundup is used by SFWD to control the vegetation along water system pipeline right-of-ways. Between July 1992 and December 1993, 13.7 gallons of Roundup were applied.

The Tracy WTP is located immediately outside of the watershed in Millbrae. It disposes of 1 mgd of filter backwash, as a daily average, to the San Andreas Reservoir. The distance between the backwash outlet and the filter plant intake in the reservoir, is approximately 300 feet. There are no data regarding backwash settling times; a study was conducted several years ago to characterize the backwash, but settling/detention analyses were not included. Because of the potential presence of microorganisms in the backwash water (filtered out during the filtration process), the backwash water should not be disposed of in the reservoir. For this reason DHS is already working with utilities throughout the State to halt this practice of backwash water disposal.

The covered "balancing reservoir" described in Section Two and located near the Pulgas Water Temple, contains water from the Bay Division Pipelines which has had chlorine added to it. Although this water does not pose drinking water quality concerns, it is of concern to wildlife and vegetation during the infrequent occasions when the balancing reservoir is drained to Crystal Springs Reservoir.

PROJECTED CHANGES IN SOURCES OF CONTAMINATION

Caltrans is currently planning the expansion of Highway 92 from two lanes to four lanes through the watershed. To minimize the potential water quality impacts associated with the Highway 92 expansion project, SFWD has been worked closely with Caltrans. Mitigations such as slope and erosion control, sedimentation basins, and seasonal controls will be included in the design to avoid construction impacts. The SFWD is also negotiating with Caltrans to provide a permanent turbid water collection pond which would prohibit roadway water from draining to the reservoirs. Caltrans is to provide a drawing of the project which will be forwarded directly to DHS. The expanded highway is intended to reduce accidents occurring due to the high volume of traffic and to accommodate planned increases in usage. The increased usage of Highway 92 and I-280 will increase the risks associated with accidental spills of hazardous materials; storm drainage overflows would also contain higher quantities of hydrocarbons and other products associated with automobiles.

Filoli Estate is planning modifications to its facilities on its own land and land leased from SFWD. Being planned are the following facilities: a new visitor/education building, new access road off of Canada Road to separate delivery circulation from visitor circulation, and regrading and widening an abandoned access road.

There are no other planned land use or activity changes which may result in a change to potential contaminant sources within the Peninsula watershed.

SIGNIFICANCE OF POTENTIAL CONTAMINANT SOURCES

The risk of accidental spills along Highway 92 where it crosses Crystal Springs Reservoir is of utmost concern. In addition, the runoff from this highway currently drains to the reservoirs. As mentioned above, Caltrans is planning to expand the highway and is including provisions to pump the stormwater runoff out of the watershed. However, because Highway 92 is directly over Crystal Springs Reservoir, the reservoir is still vulnerable to major spills and vandalism. Since the stormwater runoff from I-280 is pumped out of the watershed it is not considered a significant concern, however, the risk of accidental spills which could overflow from or avoid the drainage facilities is considered significant due to the proximity of the highway to the waterbodies.

The Filoli Estate should be monitored more closely in two areas: the septic systems and the buried fuel tanks, both of which may significantly impact Crystal Springs Reservoir. The Estate managers appear to be limiting their chemical usage.

The risk of fire is great in this watershed; this could significantly impact the reservoir water quality. Although it is not a common occurrence, the natural gas pipelines may rupture and cause a fire. Asbestos fibers are of concern particularly in the Peninsula watershed due to the great extent of serpentine rock on the west side of the watershed.

The Crystal Springs Golf Course is not monitored for specific water quality concerns; not enough data are available to determine the contribution of nutrients and pesticides to watershed waterbodies. Additional information is also needed on the source of pathogens within the watershed. Data indicate that microorganisms are found in the reservoirs; it may be from wildlife, livestock around the periphery of the watershed, and/or from the heavy recreational users not using toilet facilities. Along this same subject, the fitter backwash practices at the Tracy WTP may be considered a significant potential source of contamination because of the disposal of the backwash water into San Andreas Reservoir.

Lastly, a potential significant source of contamination is the Skyline Quarry. Runoff water quality data is not available for this area which would aid in understanding the impacts the site (metals, oil and grease) may have on watershed water quality.

SECTION 9

WATERSHED CONTROL AND MANAGEMENT PRACTICES

SAN FRANCISCO WATER DEPARTMENT ORGANIZATION AND PRACTICES

The San Francisco Public Utilities Commission oversees the functions of the SFWD, the Hetch Hetchy Project, and various Bureaus, as presented in Figure 9-1. This section provides a brief description of the Hetch Hetchy Project and Utilities Engineering Bureau (UEB) as their functions relate to the SFWD, and an overview of the primary divisions within the SFWD. The divisions within the SFWD with authority over activities related to watershed management are described in greater detail than the other divisions and departments.

Utilities Engineering Bureau

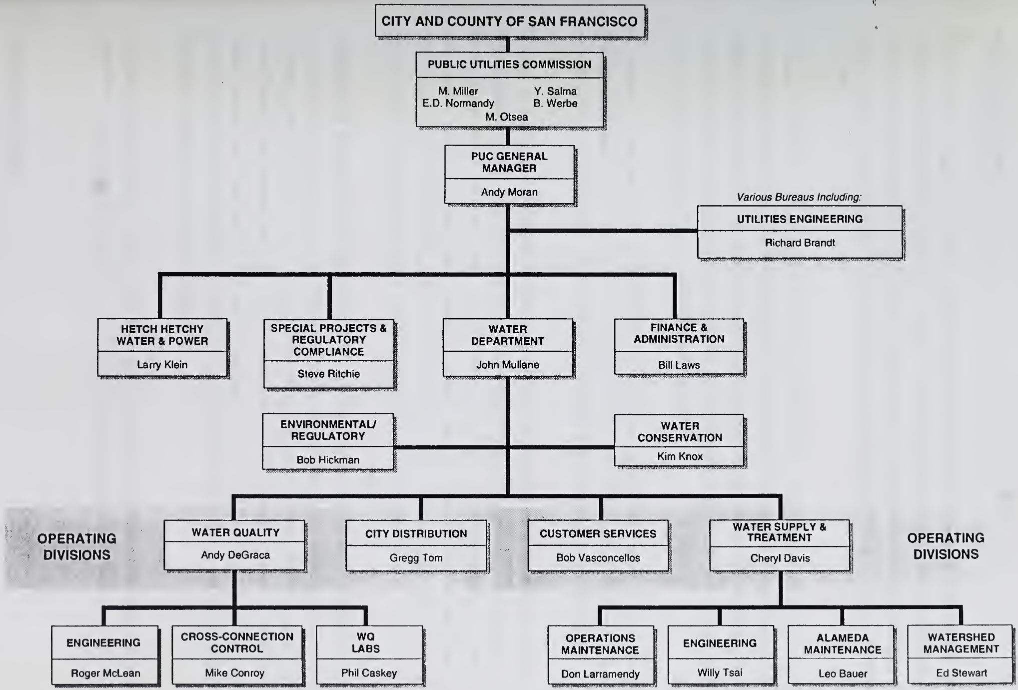
The UEB is responsible for designing and constructing major capital improvement projects. This bureau is staffed with design engineers who conduct or contract for specific engineering, environmental, construction management, and related services for the Water Department and the Hetch Hetchy Department to implement components of the Public Utility Commission's major capital improvement plans.

Hetch Hetchy Water and Power

The Hetch Hetchy Project manages the Sierra Nevada watersheds and reservoirs and water conveyance facilities as far west as the Alameda East Portal of the Coast Range Tunnel. This department also manages the power production and transmission facilities from the Sierra's to the Newark Substation where PG&E then wheels the power for the City. The Hetch Hetchy Project supplies the prearranged flow of water from the Hetch Hetchy system to the SFWD system at the Alameda East Portal. The flow rate is set by the SFWD and is limited to the capacity of the three San Joaquin Pipelines. Depending on the seasonal demand and the water levels at the primary storage reservoirs, the SFWD may request changes of flow rate four to five times a year.

Special Projects

This is a new division; roles and responsibilities are being determined.



MONTGOMERY WATSON
June 1995

SAN FRANCISCO WATER DEPARTMENT ORGANIZATION

FIGURE 9-1

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Water Department

The SFWD manages the water system downstream from the Alameda East Portal, which includes all of the local sources of supply, transmission, water treatment, distribution, and billing. In addition, the Rock River lime treatment and Tesla chlorination stations, as well as water quality monitoring activities, all physically within the Hetch Hetchy system, are managed by SFWD.

Within the SFWD are several primary divisions and sections. The primary division responsible for managing the watersheds is Water Supply and Treatment with a significant role played by the Water Quality division. The sections which also oversee activities within the watershed include the Special Projects, Lands, and Environmental and Regulatory Affairs sections. Other sections, do not contribute significantly to watershed management.

As stated in Section One, the SFWD is currently undergoing development of a watershed management plan which may result in changes to the operations and management activities occurring with the watersheds. The final plan will be provided to DHS upon completion.

Water Supply and Treatment Division. The Water Supply and Treatment Division is headquartered at the Millbrae office and is responsible for the operation and maintenance of the storage, treatment, transmission, and distribution facilities from the Alameda East Portal downstream to the San Francisco County line where the City Distribution Division takes over. The Water Supply and Treatment Division is further divided into the Engineering, Operations Maintenance, Alameda Maintenance, and Watershed Management sections.

Engineering Section. The Engineering Section is responsible for all water supply and system planning and engineering, and the operation of the physical facilities and system between the Alameda East Portal and the San Francisco County line (plus the Rock River lime treatment and Tesla Portal chlorination station). The operation of the filter plants, treatment facilities, and pump stations are also under this section although activities involving these facilities are coordinated with the Water Quality Division. Capital improvement plans are developed in this Section in conjunction with other sections.

The Engineering Section works closely with the Alameda and Operations Sections because the operations and maintenance staff can be found in the geographically based groups. Land

engineering functions are also conducted by this section; these responsibilities include interacting with developers for construction easements and maintaining property records.

Alameda Maintenance Section. This section is responsible for the daily operations and maintenance of the system and watershed areas west of the Alameda East Portal and east of Coyote Creek (along Bay Division Pipeline Nos. 3 and 4) and the Dumbarton Valve House (Bay Division Pipeline Nos. 1 and 2), except for the pump stations and the Sunol WTP (managed by the Engineering Division).

Operations Maintenance Section. This section is responsible for daily operations and maintenance of the system and watershed areas west of Coyote Creek (along Bay Division Pipeline Nos. 3 and 4) and the Dumbarton Valve House (Bay Division Pipeline Nos. 1 and 2), except for the pump stations and the Tracy WTP. All customer meters outside of the City are maintained by the Customer Services section of this group.

Watershed Management Section. Responsibility for management of the Alameda and Peninsula watershed areas is the primary function of the Watershed Management section. Some members of the Watershed Management section are Registered Professional Foresters licensed by the State of California, fulfilling the State's requirement for management of the wildlife resources and watersheds. Watershed policy and project plans are developed by this section; the development of the Watershed Management Plan, discussed previously, is being managed from this section. Watershed protection, operations, maintenance, restoration, improvement, and enhancement activities are planned, reviewed, and/or approved by this section. Day to day execution of these activities is performed by the Alameda and Peninsula Operations sections. In addition, Lands section staff (discussed below) administer activities on watershed lands performed by leasees and other third party interests.

The Watershed Management section is also responsible for specific technical studies such as hydrological studies, and for overseeing special projects related to land use activities within the watersheds. This group coordinates specific tasks with the Water Quality Division such as developing a water quality monitoring program and addressing hazardous materials issues, and controls the permitting system for allowing the public onto the watershed lands. This section is currently undertaking the development of the Sunol Valley Resources Management Plan. The Resources Management Plan is addressing diverse issues specific to Sunol Valley. The primary components of the plan include the analysis of existing conditions and the determination of future configurations of gravel extraction operations in order to create water storage reservoirs;

the development of a plan for a water release and recapture program on Alameda Creek to enhance fish habitat; and an operations plan to coordinate the above two programs with the existing and future water conveyance and treatment system within Sunol Valley. The findings of this study will be incorporated into the Alameda Watershed Management Plan.

A Fire Management Plan is also being developed by the Watershed Management section for the Alameda and Peninsula watersheds. Fuel loadings and fire hazard will be assessed. A management and implementation plan will be developed for both watersheds which will include fire management policies, areas needing action, recommended management techniques for at-risk areas, a maintenance program, and a day to day operations plan. A Range Management Plan is also being developed for the Alameda watershed. The 30,000 acre leased areas will be inventoried and analyzed to provide the basis for transitioning to an animal unit month-based grazing management system. The plan is based upon concepts consistent with vegetation and water quality goals. The plan provides for a reduction in the grazing season when necessary, introduces stock-rotation, and improves livestock distribution through additional fencing and conservative utilization standards. Stocking rates have been revised to reflect a reduction in the current program of 11 percent. The plan also provides vegetation monitoring, a riparian grazing policy, wildlife compatibility, and lessee accountability. This work is being coordinated for consistency with the EBRPD's system to enable EBRPD and SFWD to manage grazing cooperatively and establish effective grazing unit boundaries.

Watershed Maintenance. The maintenance functions are coordinated within sections of the Water Supply and Treatment Division discussed above, by the watershed keepers and maintenance staff. There are six watershed keepers located at the Sunol headquarters and eight out of the Millbrae offices. The primary duty of the watershed keepers is to survey the watershed and identify conditions which need attention. The duties of the watershed keepers also include patrolling for security problems, performing lake level readings, and maintaining ongoing relations with County Departments, the California Department of Forestry, and recreation districts. Several watershed keepers have residences within the watershed which provide an indirect form of policing of the lands.

Water Quality Division. The Water Quality Division is headquartered in Millbrae and is responsible for water quality throughout the entire system, including Hetch Hetchy. This division also operates the laboratory and is responsible for cross connection control.

[illegible]

Lands Section. The Lands Section, within the Finance and Administration Division, is responsible for leases and permits for SFWD lands within the watersheds and rights-of-way. The manager of the Lands Section does not report directly to the Water Supply and Treatment Division, however, several Lands Section staff report to the Alameda Manager on a daily basis.

As a part of developing and overseeing the lease agreements, the Lands Section has the authority to identify specific lease requirements related to water usage, sanitary facilities, runoff control, grazing locations, pesticide and herbicide applications, changes in land uses, emergency responses, and water quality monitoring. However, the current leases do not consistently identify strict monitoring of activities. This issue is being addressed in the Watershed Management Plans being developed with input from the Lands Section.

Other Divisions. The City Distribution Division is headquartered at 1990 Newcomb Avenue in San Francisco and is responsible for water supply distribution engineering, construction, and maintenance throughout the City and County of San Francisco.

The Customer Service Division is headquartered at 425 Mason Street in San Francisco and is responsible for customer services and accounts, the water rationing program, and field services.

OTHER AGENCIES WITH WATERSHED CONTROL AUTHORITY

There are numerous local, State, and Federal agencies which have authority over or responsibilities towards land uses and activities which may impact water quality within the Alameda and Peninsula watersheds.

Other Agencies

Table 9-1 identifies the primary relevant agencies and just the responsibilities related to controlling watershed land uses and activities which may impact water quality. Some agencies have regulations and permits, others have cooperative agreements or protection authority.

TABLE 9-1

AGENCIES WITH WATERSHED WATER QUALITY CONTROL AUTHORITY

Agencies	Area of Responsibility
Alameda Watershed Local Agencies	
Alameda Co. Dept. of Environmental Health	Septic systems Hazardous materials business plans Inspection of hazardous materials storage and USTs
Alameda County Fire Dept.	Fire protection Storage of hazardous materials Emergency response
Alameda County FC&WCD	Storm drainage system
Alameda County Office of Emergency Services	Emergency planning and response
Alameda County Planning Department	General plan/zoning land use changes Use permits Environmental Compliance Quarry activities
Alameda County Public Works	Construction activities: erosion control Maintenance of county roads Building Permits
East Bay Regional Park District	Manage recreation lands
Santa Clara County Planning & Development	General plan/zoning land use changes Building and use permits Environmental Compliance Construction activities: erosion control Flood control/stormwater drainage with SCVWD
Santa Clara County Office of Emergency Services	Emergency planning and response
Santa Clara Co. Dept. of Environmental Health	Septic systems Hazardous materials business plans Inspection of hazardous materials storage and USTs
Santa Clara County Transportation Agency	Maintenance of county roads
Santa Clara County Fire Marshall	Fire protection with CDF Emergency response with CDF Storage of hazardous materials
Santa Clara County Parks and Recreation	Manage its recreation lands
SCVWD	Nonpont source program with County Planning Flood control/stormwater drainage with County Planning

TABLE 9-1 (continued)

AGENCIES WITH WATERSHED WATER QUALITY CONTROL AUTHORITY

Agencies	Area of Responsibility
Peninsula Watershed Local Agencies	
San Mateo Co. Environmental Health Division	Septic systems Hazardous materials business plans Inspection of hazardous materials storage and USTs Landfill inspection
San Mateo County Fire Department	Storage of hazardous materials Emergency response with CDF Fire protection with CDF
San Mateo County Office of Emergency Services	Emergency planning and response
San Mateo County Parks Department	Oversee Peninsula watershed public trails
San Mateo County Planning and Building Div.	General plan/zoning land use changes Building and use permits Environmental Compliance
San Mateo County Public Works	Construction activities: erosion control Maintenance of county roads Storm drainage system
San Mateo County Sheriffs Office	Explosive materials handling
State Agencies	
Caltrans	Highway runoff collection
Department of Fish and Game	Wildlife management within refuge Responsible for State listed species Water quality for aquatic species
Department of Forestry	Fire protection and emergency response Timber harvesting
Department of Health Services	Drinking water quality Treatment and system changes
Department of Toxic Substances Control	Generation/storage of hazardous waste
Fire Marshal's Office	Petroleum pipelines
Integrated Waste Management Board	Solid waste storage facilities

TABLE 9-1 (continued)

AGENCIES WITH WATERSHED WATER QUALITY CONTROL AUTHORITY

Agencies	Area of Responsibility
Regional Water Quality Control Board	Discharge of waste into waterbodies (soil, nonpoint runoff, point discharges, construction over 5 acres) Hazardous waste surface impoundment Mines and quarries
Federal Agencies	
Army Corps of Engineers	Construction activities in waterbodies and wetlands
Environmental Protection Agency	Hazardous waste generators NPDES primacy given to RWQCB Drinking water primacy given to DHS
Federal Energy Regulatory Commission	Petroleum pipeline
Fish and Wildlife Service	Water quality impacts to federally listed species

The various County agencies identified in Table 9-1 with responsibilities of construction and maintenance activities do not always have policies which are water quality protection oriented. Several of the State and Federal agencies have permitting authority over construction activities and do have a vested interest in water quality protection, but they are typically only involved with watershed lands if there is construction proposed or occurring. The DHS and RWQCB have the most involvement in the watersheds on an on-going basis. DHS regulates drinking water quality which is influenced by watershed conditions, and the RWQCB has policies and regulations pertaining to discharges to waterbodies impacting water quality. In addition, several agencies listed in Table 9-1 have emergency response authority and are critically important to the protection of water quality in the watersheds.

The SFWD and RWQCB are currently participating in a regional effort, the Southern Alameda Creek Watershed Project, which is being managed by the Alameda County Resource Conservation District. The primary goals of the project are to develop and apply proper management strategies to restore, protect, and improve water quality and biodiversity of the southern Alameda Creek watershed. Partnerships among stakeholders are being developed to encouraged voluntary adoption of improved management strategies. SFWD is a key participant

[illegible]

in this program. 1995 Coliform data from the monitoring of upper Alameda Creek which were obtained for this project by the RWQCB have been recently provided to DHS for their files.

The Alameda watershed is within both Alameda County and Santa Clara County; the Peninsula watershed is entirely within San Mateo County. The General Plans of Alameda County and Santa Clara County have the most direct impact on watershed land uses and activities outside of SFWD-owned lands. Since the majority of Peninsula watershed lands are owned by SFWD, the San Mateo County General Plan has less of an influence. Programs and policies of the General Plans for Alameda County, Santa Clara County, and San Mateo County which may impact land uses and water quality are provided below.

The City and County of San Francisco Master Plan, adopted in 1990, contains only one reference to these watershed lands: "Public access should be provided by the SFWD to portions of its watershed lands which have high recreational value, subject to restrictions required to protect water quality and water production, rare and endangered plant and animal species, and preserve wildlife habitats, archaeological and natural resources (I.3.4)." It should be noted, however, that the Planning Commission does not have planning authority over City watershed lands.

Alameda County - East County Area Plan Policies

The Alameda County Planning Department has prepared a draft of the East County Area Plan (ECAP), a supplement to the County General Plan focusing on the east county. The study area includes the Alameda watershed north of the Santa Clara County border. ECAP was drafted in 1993 and is, as of this date, undergoing public review and input. Planned land use changes associated with the preferred alternative have been identified in Section Seven, Potential Contaminant Sources, of this WSS. The policies described below are all draft policies and the underlining emphasis is as provided for in the ECAP.

ECAP proposes to establish an Urban Growth Boundary "to provide certainty regarding development potential for long-term infrastructure financing, agriculture investment, and environmental protection." The SFWD watershed lands are designated as Watershed Resource Management in the plan. ECAP addresses open space lands specifically in relation to proposed city expansion plans. The City of Fremont's 1991 General Plan "...contains policies regarding Fremont's potential expansion into unincorporated land located in the Sunol subarea. The City has included the Vargas Plateau and Sheridan Road (on and/or east of the ridge line and northwest and southeast of I-680 respectively) within the planning area." The ECAP proposed

plan concludes that the Sunol area should be maintained primarily as unincorporated county land open space. All proposed growth alternatives in ECAP protect the Sunol Valley from inclusion in the boundaries of an incorporated city and thereby from increased urbanization.

Policy 102 states that "The County shall encourage public water management agencies to explore recreational opportunities on watershed lands, particularly reclaimed quarries, where recreational use would not conflict with watershed protection objectives". Policy 103 states that,

> "The County shall encourage the San Francisco Water Department to provide limited public access on trail corridors through the watershed lands surrounding San Antonio and Calaveras Reservoirs, Sunol Watershed, and the Arroyo de la Laguna. The County shall work with the East Bay Regional Park District to incorporate these watershed corridors into the regional trail system, where recreational use would not conflict with watershed protection objectives."

Program 25 states that, "The County shall work with...the San Francisco Water Department to incorporate continuous open space areas outside the Urban Growth Boundary into the Bay Area Greenbelt system."

Program 66 states that, "The County shall work with the San Francisco Water Department to develop a land use and reclamation plan for San Francisco Water Department-owned land in the Sunol Valley. The plan shall ensure the compatibility of the quarries with the Sunol Community during active mining and following reclamation. Opportunities for habitat preservation and enhancement and recreational uses should be explored in conjunction with reclaimed uses."

Policy 104 could have important implications for the Alameda watershed,

> "The County shall designate an area outside of the San Francisco Water Department lands that extends to the limit of the watershed boundary as "Resource Management". Within this area the County shall encourage land use activities to adhere to management guidelines developed for the protection of watershed lands and shall ensure that subdivisions of lands or quarry operations and reclamation plans within this designation shall be approved only where such subdivisions or quarry operations would not adversely affect the watershed protection of the San Francisco Water Department."

Policies 144, 145, and 146 also address quarry development. "ECAP allows quarrying within the Large Parcel Agriculture, Resource Management, Watershed Management, Urban Reserve, and

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Quarries land use designations ". Policy 150 deals with the Sunol Valley quarries. "The County shall participate with the San Francisco Water Department in its planning efforts for SFWD-owned watershed lands within the Sunol Valley to ensure that future quarry activity is compatible with Sunol community interests and water management objectives."

Policy 153 states that quarry "reclamation plans are designed to restore biological value to sites through appropriate revegetation, contouring of lakes to simulate natural bodies of water, and protection or in-kind replacement of significant trees."

Chapter 5.8, Visual and Aesthetic Resources, discusses the Sunol Water Temple: "In Sunol, the view from the road of the Water Temple (part of the City of San Francisco's Hetch Hetchy system) provides a unique visual landmark." Chapter 5.8 also states that the Niles Canyon Road between Mission Boulevard and I-680 is expected to be designated a California State Scenic Highway.

Policies 114-116 relate to proposed grading requirements to be developed by Alameda County. Policy 114 specifies that "The County shall require that where grading is necessary, the off-site visibility of cut and fill slopes and drainage improvements is minimized. Graded slopes shall be designed to simulate natural contours and support vegetation to blend with surrounding undisturbed slopes." Policy 115 specifies that "The County shall require that grading avoid areas containing large strands of mature, healthy vegetation, scenic natural formations, or natural watercourses. Policy 116 specifies "The County shall require that access roads be sited and designed to minimize grading."

Santa Clara County General Plan

The Santa Clara County General Plan was prepared by the County Planning Department's Advance Planning Office and adopted in 1981. The General Plan designates land uses within the Alameda watershed owned by SFWD as Resource Conservation Area-Other Public Open Lands, and remaining lands as Resource Conservation Area Hillsides, Ranchlands, and Existing Regional Parks. Several small areas are designated as Rural Residential Areas. The General Plan identifies the development of a Calaveras Reservoir Park and Ecological Reserve.

Policy CE 2 states that "Urban development should occur only within urban service areas and under city jurisdiction (E-6)." Urban Service Areas are proposed to be areas "without cumulative adverse impacts on the county's watersheds and other resources (E-6)." Policy CE 4 states that

watershed lands, generally above 15 percent slope, are considered unsuitable for urban development.

Policy NE 19 specifies the protection of water resources by:

a. Preserving open land in both agricultural and hillside watershed areas.

b. Preserving areas with prime percolation capabilities and avoiding placement of all potential sources of pollution in such areas.

c. Minimizing sedimentation and erosion through control of grading, quarrying, cutting of trees, removal of vegetation, placement of roads and bridges, use of off-road vehicles, and animal related disturbance of the soil.

d. Avoiding pollution by not allowing the location of septic systems, automobile dismantlers, waste disposal facilities, industries utilizing toxic chemicals, and other potentially polluting substances to be in creekside or residential areas when polluting substances could come in contact with floodwaters...or reservoir waters.

e. Avoiding establishment of excessive concentrations of septic systems over large land areas, and mitigating water quality impacts from existing concentrations.

Policies relating to the natural environment specify controlling the use and disposal of pesticides, herbicides, toxic chemicals, and agricultural chemicals in Santa Clara County. Reducing or eliminating the use of broadcast herbicide by public agencies is a County policy. Control of surface runoff by implementing the recommendations of the Regional Environmental Management Plan is also a policy.

Santa Clara County is currently undergoing an update of the County General Plan. The draft is expected to be released to the public for review during 1994.

San Mateo County General Plan

The San Mateo County General Plan was prepared by the Department of Environmental Management and was adopted in November 1986, with updates of certain elements since 1986.

Lands within the Peninsula watershed are designated as General Open Space. The following policies apply to the watershed lands.

Policy 1.36 requires the protection of water resource lands productive uses.

Policy 4.22 specifies the protection of the basic scenic character of forest lands by promoting the regulation of thinning and commercial harvesting.

Policy 6.1 specifies the provision for a balanced and equitable system of park and recreation facilities that meet identified needs of San Mateo County residents. The plan includes the SFWD watershed in a recreation easement.

Policy 7.22 states that watershed lands are unsuitable for inclusion within city spheres of influence.

SFWD lands are specifically discussed under Policy 9.43: "Recognize the San Francisco watershed lands as unique areas of special open space significance that should be protected from conflicting land uses in order to retain their value as open space, wildlife, water supply, and recreation resources."

Policy 9.5 specifies continuance of the cooperative management of the SFWD watershed lands by the County, the City and County of San Francisco, the State of California, and the Golden Gate National Recreation Area.

Policy 10.2 calls for safeguarding the productive capacity of ground water aquifers and storage reservoirs.

SECTION 10

RECOMMENDED CORRECTIVE ACTIONS

Due to an ever increasing regulatory emphasis on raw water quality and corresponding treatment requirements, recommendations are made here to strengthen the first barrier to water quality degradation - protection of the source watersheds. The second barrier, treatment of local runoff, has been designed by SFWD to remove an array of water quality parameters to meet the changing drinking water regulations. SFWD's two WTPs have performed well from a historical standpoint. However, as the regulations continue to become more stringent and complex, modifications to the existing plants and/or new processes must be added to meet these demanding regulations.

As a result, the cost of treatment continues to increase as well as the complexity of day-to-day operations. With regards to operations, as the WTPs become more challenging, the resulting impacts of human error and inadequate process performance can lead to regulatory violations which can impact public health (e.g. the cryptosporidiases outbreak in Milwaukee) or environmental conditions (e.g. fish kills due to accidental releases of process water from treatment plants into streams).

In addition, as the drinking water industry's knowledge regarding water quality contaminants increases due to improvements in analytical tools and techniques for evaluating health effects, further changes to existing water treatment processes and operations will need to be incorporated. For example, within the last five years a monitoring approach and an analytical tool have been in development which allows the industry to identify *Cryptosporidium*, a microbiological parameter. As the drinking water industry begins to understand more about this microbe, it recognizes the challenges it represents from a treatment standpoint. Chlorine which has traditionally been added to control microbes is ineffective in controlling *Cryptosporidium*; instead, the primary control process for *Cryptosporidium* is filtration.

Another example of increasing industry knowledge is the suspected carcinogens formed during the disinfection process. For both of these examples, a viable option is to control the raw water quality at the source in an attempt to control the level of treatment required. As new parameters continue to be identified and the drinking water industry's knowledge

regarding existing parameters increases, the source control option will become a more important approach used by utilities.

This information is important for SFWD to keep in mind when considering additional uses or maintaining and managing specific existing land uses within the watersheds. More information is needed on the characteristics of the watersheds and specifically how these characteristics may be affecting water quality.

The following recommendations were developed from the analyses presented in the previous sections of this Watershed Sanitary Survey. These recommendations are made for the express purpose of improving overall watershed protection and maintaining drinking water quality. These recommendations are grouped by the following subjects: water quality monitoring, watershed control and management practices, interjurisdictional coordination, and public education. Corrective actions recommended here are indicated in italic type, discussion and explanation are in plain type.

WATER QUALITY MONITORING

- ❑ **Watershed Monitoring Program.** Watershed water quality monitoring programs are critical in order to identify contaminant sources and quantify the influx of parameters which may degrade the quality of raw water reaching the reservoirs both within and upstream of SFWD lands. The monitoring programs which are recommended below need to be developed further with specific locations, parameters to be monitored, frequencies, types of sampling, seasonal conditions, etc. identified. It is important to establish monitoring programs now at tributary entrance points to SFWD lands in order to establish a baseline water quality database to use in detecting future changes in water quality.

  - ***Develop a monitoring program to assess the in-stream loadings generated by watershed runoff: particulates, microbial organisms and pathogens, DBP precursors, nutrients, TOC, and synthetic organic compounds.*** The data are essential to identify sources, measure the efficacy and costs of management, modify or eliminate the activities, and identify capital improvements designed to attenuate or eliminate the effect on water quality.

Recommended Corrective Actions

- ***Establish and operate water quality (and stream flow, as appropriate) monitoring stations along tributaries on or near SFWD lands which contain leased and City-operated land uses, as well as land uses on private lands within the watersheds which may be contributing contaminants.*** A monitoring program is imperative and should be developed to determine the contribution of particular water quality contaminants from these land uses for the development of effective management strategies and lease requirements, and for working with adjacent land owners in reducing contributions of contaminants. The monitoring programs must be developed specific to each land use.

  For example, the golf courses in each watershed should be monitored for nutrients, herbicides, fungicides, ammonia, TOC, turbidity, UV, and coliforms (total and fecal, near effluent disposal areas), metals, hydrocarbons, pH, and PAH. The quarries should be monitored for ammonia, BOD, coliforms, HPC, metals, MBAS, nutrients, pH, temperature, TOC, and UV.

- ***Design and implement a water quality and stream flow monitoring program for tributaries at entry points to SFWD lands (particularly within the Calaveras Reservoir watershed).*** Data are needed to determine the contribution of certain water quality parameters and flows from outside the extent of SFWD land holdings. In particular, water quality monitoring is needed of nutrients, pathogens, and organic carbon parameters. This information is required to identify and monitor indications of water quality degradation trends and for the development of effective watershed management strategies.

- ***Determine the amount of in-stream loadings associated with existing and planned land uses and activities.*** These data are needed to aid in projecting the cumulative long term impacts of future land use changes throughout the watersheds. If enough data are collected, these actions would provide a quantitative basis for comments on land use changes proposed outside of SFWD lands.

- ***Utilize selective composite sampling, where appropriate, to maximize the information obtained from expensive analytical tests.*** Composite sampling refers to a mixture of grab samples collected at the same sampling point at different times over a short duration (e.g. 24 hours). These are most useful for

observing average concentrations that will be used in evaluating conditions, but this method cannot detect peaks. Composite sampling can be used to improve the representative nature of a monitoring program. For example, sampling for pesticides in residential neighborhoods may lend itself to composite sampling.

- **Augmentation of On-Going Water Quality Monitoring Program.** The existing water quality monitoring program is adequate to determine the current level of required treatment. However, the following components are recommended to augment on-going monitoring to provide additional data to characterize the raw water qualities and respond to anticipated changes in drinking water regulations.

  - Transfers from the State Water Project via the South Bay Aqueduct affect the water quality in San Antonio Reservoir. ***Incorporate the following parameters in the ongoing monitoring programs. Coordinate the monitoring of these parameters with the recording of water transfers in order to establish correlations with the imported supplies.*** This will aid in distinguishing between the water quality impacts generated by imported supplies versus those constituents originating from within the watershed.
    1) bromide
    2) TOC and/or UV-254 absorbance
    3) zebra mussels, other biological pests or predators
    4) algal counts and identification

  - Conductivity and total dissolved solids in Pilarcitos Reservoir have gradually increased in recent years. ***Conduct regular review of the sampling results to determine whether these trends are within normal fluctuations.***

  - ***Add semi-annual sampling of finished water from the two treatment plants for metals (in particular iron and manganese), organics, sodium, color, and other regulated constituents to the monitoring program.*** However, the current sampling program of raw waters should be maintained because it provides an important historical water quality database reflecting watershed conditions.

- **Groundwater Characterization.** ***Compile and review existing information on groundwater underlying Arroyo de la Laguna in the Alameda Watershed to characterize subsurface conditions and understand interrelationships between***

Alameda Creek and Arroyo de la Laguna. In the event of a spill into Arroyo de La Laguna and Alameda Creek, this information could prove critical in mounting a timely and effective response and minimizing the impacts to the Sunol Filter Galleries. However, the SFPUC recently accepted a recommendation that the Alameda Creek flows be rediverted into the supply system at a location upstream from the filter Galleries near the Sunol WTP. Until the time that the diversion point is relocated, protection of the Filter Gallery watershed is very important to maintaining all of the SFWD water supplies for use in the future. Additional land uses, activities, and disturbances should not be allowed near the galleries nor near the contributing surface waters. Once additional monitoring data is obtained, as recommended above, some existing uses may need to be removed.

❑ **Reservoir Management.** Although in-reservoir treatment, operations, and management recommendations are beyond the scope of this watershed sanitary survey analysis, two general recommendations are provided here.

- SFWD efforts have greatly reduced copper sulfate applications used to control algae while maintaining a high standard of protection of human health. ***Find and test alternative methods of algal control while continuing to minimize the use of copper sulfate.***

- To aid in future reservoir water quality management decisions, additional monitoring should begin now. ***Augment existing monitoring program with the following parameters: dissolved organic carbon, total nitrogen, and total phosphorus.***

WATERSHED CONTROL AND MANAGEMENT PRACTICES

Land uses and activities within the watersheds increase the risks to water quality. Tailoring management and control efforts to specific uses within watersheds is required to minimize risks associated with specific land uses and activities.

❑ **Water Quality Vulnerability Zones.** As a part of the Watershed Management Plan process, watershed zones were developed which indicate areas most vulnerable to the contribution and transport of water quality contaminants of concern (see Appendix D). Over time, development of loading estimates and threshold criteria may be added

to augment the vulnerability zone database. Recommendations related to utilizing the vulnerability zone analysis and its results include the following.

- *Utilize the vulnerability zone maps to plan for future land uses and activities.*

- *Avoid the high vulnerability areas for the particular water quality parameters impacted by the planned facility or activity.*

- *Minimize water quality impacts in areas of moderate and low vulnerability.*

- *Collect additional data to enhance the water quality vulnerability zone analysis database. In particular - monitor soils for total organic carbon, nitrogen, and phosphorus.*

❑ **Cattle Grazing.** SFWD is currently studying approaches to grazing management for the Alameda Watershed. To reduce the risk of pathogenic contaminants, a restrictive approach to grazing will be implemented which will further reduce the numbers of existing cattle while grazing on a rotational basis. Grazing management will emphasize water quality protection and monitoring. Fencing and water supply improvements are being implemented to protect primary waterbodies from the cattle. Corrective actions related to grazing include the following.

- *Remove cattle grazing from the high vulnerability areas.*

- *Review and modify the grazing leases in the medium and low vulnerability zones to include requirements to prevent the degradation of water quality.*

- *Prevent access by cattle to waterbodies and major streams by fencing specific areas and providing water improvements to redirect cattle. In particular, fence Alameda Creek between Calaveras Dam and the Sunol WTP as specified in SFWD's recent Alameda Creek Study.*

- *Reduce cattle densities to reduce soil compaction and disturbance which leads to erosional impacts.*

- *Implement seasonal access in the grazing program.*

❑ **Incorporation of Best Management Practices (BMPs) into Leases.** Specific BMPs should be identified for all leases or easement agreements for activities on SFWD lands to minimize the risks to water quality. Specific modifications to reflect these requirements should be made to each lease when it is up for renewal, or sooner.

- ***Identify specific BMPs to protect water quality and include requirements in the lease for each individual operation and construction activity including but not limited to the following operations:***
  - golf courses in both watersheds;
  - nurseries;
  - quarries;
  - recreation uses; and
  - Filoli estate.

- ***Retain all runoff from lease sites and control the discharge. Use detention ponds, vegetative strips, grassy swales, and other methods to control the runoff volume and quality.***

- ***The Water Quality Division should develop water quality monitoring programs for all leased activities with potential water quality impacts. Terminate leases if there is a significant water quality impact or if the impact can not be mitigated by leasee.*** The monitoring programs should be designed specifically for the parameters of concern associated with the activity and should estimate contributions of contaminants, assess the efficacy of management programs, and verify compliance with regulatory, permit, or lease conditions.

- ***Include the costs associated with each monitoring program in the lease and identify financial responsibility.***

- ***Include inspection privileges and/or schedule and enforcement penalties in the lease.***

- ***Require the approval and oversight by SFWD for all ground squirrel poison applications.***

- ❑ **Land Acquisitions and Purchase of Development Rights or Conservation Easements.** There are parcels proximate to the water bodies that are privately owned, or otherwise present risk of degrading water quality in the reservoirs. SFWD ownership of lands is a primary watershed control and protection measure. ***Evaluate the feasibility of exchanging SFWD lands external to the watersheds for more vulnerable parcels within the watershed. As an alternative to land exchange, evaluate acquiring conservation easements or development rights to these parcels.***

- ❑ **Construction and Maintenance Best Management Practices.** BMPs, with the ultimate objective of protecting water quality, are needed to guide construction and maintenance conducted by City staff and contractors within the watersheds. The Watershed Management Plans being developed by SFWD will identify specific policies and BMPs for staff to utilize.

  - ***Implement specific techniques and BMPs for construction and maintenance to prevent degradation of water quality.***

  - ***Establish standard practices for disposal of excess material from construction or maintenance activities to prevent any degradation of water quality.***

  - ***Require monitoring by SFWD watershed staff for all construction activities managed by the Utilities Engineering Bureau on watershed lands, particularly around the reservoirs and tributaries.*** This includes review of erosion control measures during design of capital projects and inspection and monitoring during construction activities.

  - ***Require an environmental sensitivity analysis for all work orders and construction contracts that affect watershed lands.***

  - ***For those SFWD roads identified as exacerbating erosion, periodically regrade them and convert to all weather roads with a stable base.***

  - ***Dispose of backwash waters and sludge from the treatment facilities in a manner which protects reservoir water quality. Identify a new program for managing backwash waters from the Tracy WTP. Sludge disposal alternatives are being evaluated.***

- **Asbestos Control.** Serpentine formations and soils generally contain high asbestos concentrations. ***Plan construction or maintenance activities to avoid disturbing these areas.***

- **Body Contact.** In order to reduce the risk of pathogenic contamination, SFWD does not allow access to any of its local reservoirs or streams except to conduct operation and maintenance procedures. ***Prohibit body contact and public access to reservoir shorelines and tributaries.***

- **Septic System Management**. ***Monitor surface and groundwater for indications of failed or problematic septic systems, particular in areas adjacent to waterbodies.*** In addition to SFWD leasee facilities, attention should be paid particularly to the Filoli septic systems and the portion of Woodside east of I-280 because of its proximity to Crystal Springs Reservoir. Hunting cabins and the extensive rural residential land uses in the Alameda watershed upstream of SFWD lands should also be monitored and inspected periodically.

- **Patrolling and Surveillance**

    - ***Increase patrolling at public access points to the watersheds to reduce the incidence of illegal dumping.***

    - ***Provide additional training for watershed keepers to teach effective surveillance techniques, to educate them as to activities that result in water quality degradation, etc.***

    - ***Provide a new watershed keeper cottage at the southern end of the Calaveras watershed to increase presence and surveillance.***

INTERJURISDICTIONAL COORDINATION

In addition to implementing the specific activities recommended above for the monitoring and control of water quality impacts resulting from adjacent lands, SFWD should conduct outreach activities to establish open lines of communication with neighboring agencies and those with overlapping jurisdictions. This is important in responding rapidly and

effectively to emergencies, as well as instilling the value of water quality protection in the watersheds. Specific actions pertaining to interjurisdictional coordination include the following.

- ❑ **Watershed Designations.** SFWD should work with land use agencies which have jurisdictional control over planning and developing lands within the watersheds. The watershed lands should be designated as watershed lands with specific policies and development procedures designed for water quality protection tied to the designation.

  This watershed designation could not only aid in controlling land use impacts, but also could establish a basis for comment on future development plans urging protection or improvement of watershed water quality. The designation could refer to the development of site-specific BMPs, a concurrent monitoring program, and enforcement penalties for noncompliance, such as revoking use permits.

  - Santa Clara and Alameda Counties have designated the entire Alameda watershed as watershed lands in their respective General Plans. ***Work with Santa Clara County to include with this designation specific policies and development procedures for water quality protection. Develop model language which specifically identifies water quality protection as a goal.***

  - ***Coordinate with the Cities of Milpitas and Fremont to include this designation on undeveloped watershed lands within their spheres of influence; coordinate with the City of San Bruno to include this designation on already developed residential lands within the San Andreas Reservoir watershed. Develop model language for the agencies to use which specifically identifies water quality protection as a goal.***

- ❑ **Review of Proposed Land Use Changes.** ***Develop a process for the review of proposed land use changes to watershed lands which the City does not own.*** This review should be focused on potential water quality impacts which may result from the land use change. Establishment of review procedures with Alameda and Santa Clara Counties, and any changes to the Fremont and Milpitas spheres of influence, is recommended. Identify strategies that will provide adequate protection of water supplies. For specific development projects, input during early project phases - conceptual or preliminary design - may lead to significant coordination between

agencies and prevent costly changes during late stages and/or ineffective attempts at incorporating retrofits into the project.

❑ **Coordination with Other Agencies and Organizations**

- Current activities, such as the coordination with local agencies for riparian vegetation zone protection along Alameda Creek, will enhance the resources of the watersheds and protect water quality. ***Continue participation in watershed protection and enhancement activities with Alameda County Resource Conservation District and other agencies and organizations.***

- The California Department of Forestry (CDF), conducts controlled burns in the upper Alameda watershed near Mount Hamilton. ***Increase communications with CDF to encourage it to plan prescribed burns in coordination with SFWD.***

❑ **Emergency Response.** A comprehensive emergency response plan should address monitoring of high risk activities, internal communication and reaction procedures, outside agency notification procedures, disaster preparedness, seismic event procedures, and overall system reliability, as well as long-term activities following a disaster which would minimize water quality impacts.

- ***Develop emergency response procedures (first responder) for watershed personnel and SFWD staff for various scenarios affecting water quality - fires, floods, earthquakes, spills (including vehicle accidents), landslides, disease outbreaks, vandalism, and treatment and conveyance facility failures.***

- ***Improve emergency response procedures for seismic and other events.***

- ***Revise the existing Emergency Operations Plan to be more site specific.***

- ***Coordinate emergency response procedures with local, state, and federal agencies.***

- ***Improve radio communications between SFWD and county agencies, particularly communications with Alameda, Santa Clara, and San Mateo Counties.***

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[illegible]

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[illegible]

[illegible]

- *Establish additional communication procedures to address potential problems such as septic system failure.*

- *Once established, review and update all emergency procedures on a regular basis.*

PUBLIC EDUCATION

Public education materials on the importance of water supplies, activities that affect water quality, and water quality protection measures should be developed for the following groups and distributed. Pamphlets, videos, and signage can be particularly effective.

- ❑ **Trail Users.** Trails users of EBRPD owned or leased watershed lands and all trail users on the Peninsula watershed trails must be educated through pamphlets and signage on the importance of protecting their drinking water supplies, activities that may threaten water quality, and measures to minimize risk (e.g. appropriate methods of human sanitation in areas not equipped with toilets, minimizing erosion by staying on trails, cleaning up after dogs, etc.). ***Develop and distribute educational materials for recreational trail users.***

- ❑ **Residential and Commercial Neighbors.** Residences and businesses within or adjacent to the watershed boundaries would benefit greatly from a public information campaign focused on the identification of typical activities likely to affect water supplies, and management strategies to minimize impacts. For example, the water quality impacts of lawn care, household pesticide and fertilizer application, cleaning up oil and grease from vehicles, etc. should be described, with suggestions to avoid or mitigate the impacts. ***Develop and distribute educational materials for residential and commercial neighbors. Establish an emergency telephone number for reporting spills, illegal dumping, and indiscriminate usage of pesticides and fertilizers.***

- ❑ **Transportation Corridors.** ***Develop a signage campaign along transportation corridors through watershed lands to alert travelers to the risk and impacts on water quality from fire, vehicle accidents, and dumping and spills.***

- ❑ **Local and Regional Governments.** Local and regional agency staff and decision makers (e.g. staff from planning and public works departments, members of Planning Commissions, City Councils, and Boards of Supervisors) must be educated on the importance of protecting drinking water, and the most effective strategies to accomplish this goal. ***Develop and distribute information on sources of water quality impacts and degradation, both typical and specific to existing and planned land uses.*** The provision of this information will lay the groundwork and begin building consensus for incorporating a special watershed designation into General Plans and design review that will encourage the protection of water quality. It will also encourage cohesive coordinated planning and management.

APPENDIX A

PHOTOGRAPHS OF WATERSHEDS

Skyline Trail Bike Path

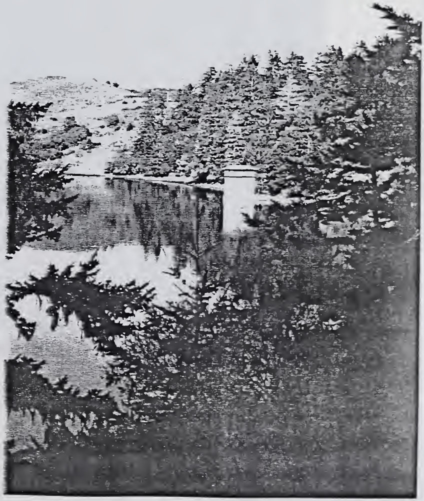
Cahill Ridge

Crystal Springs Reservoir

Residential Development Adjacent to Crystal Springs Reservoir

San Andreas
Reservoir
looking north

Pilarcitos Reservoir Intake
Structure to San Andreas
Reservoir

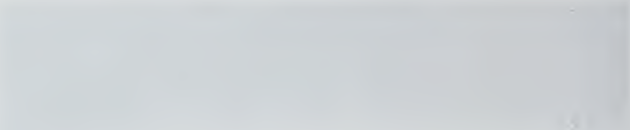


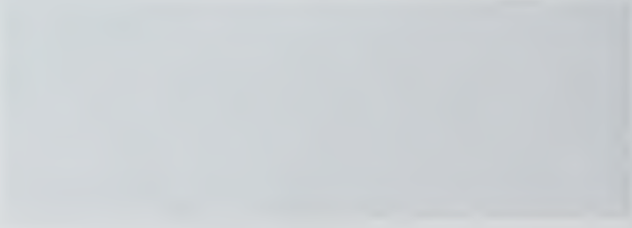
Nurseries along Alameda
Creek in Sunol Valley

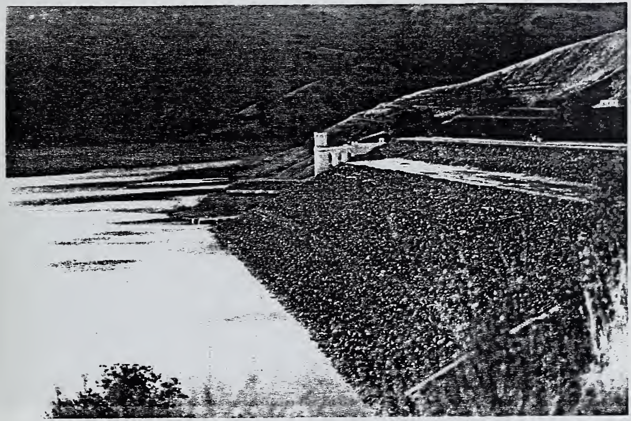
Quarries in Sunol Valley

La Costa Valley
in San Antonio Watershed

San Antonio Reservoir
looking north

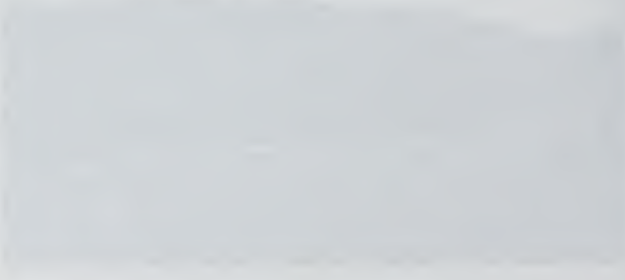




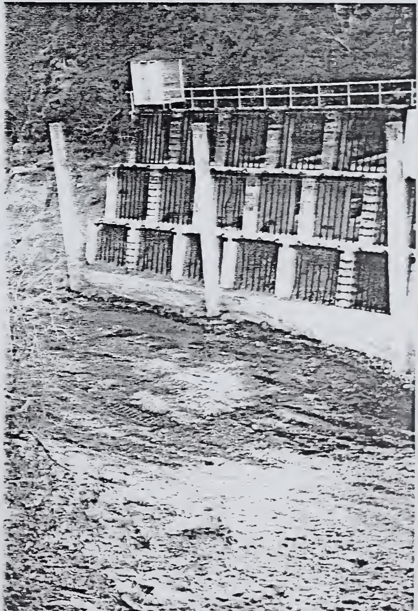


Calaveras Dam
and Intake Structure

Residential Development
in Calaveras Watershed



Alameda Creek
Watershed
above Diversion
facility



Alameda Creek Diversion
Inlet to Calaveras Reservoir

APPENDIX B

ORGANIC CHEMICAL ANALYSES

ORGANIC CHEMICAL ANALYSES (3/93)

Date of Report: 940118 Sample ID No. ________

Laboratory Name: San Francisco Water Dept. Signature Lab Director: [signature]

Name of Sampler: D. Dingman Employed By: San Francisco Water Dep

Date/Time Sample Collected: 9310131025 Date/Time Sample Received @ Lab: 9310131315 Date Analyses Completed: 931018

System Name: City of San Francisco System Number: 3810001

Name or Number Of Sample Source: Calaveras Reservoir

User ID: E N G Station Number: D 3 8 / 0 0 1 - C L V R S - R

Date/Time of Sample: 9 3 1 0 1 3 1 0 2 5 Laboratory Code: 9 5 5 3
Y Y M M D D T T T T

Date Analyses Completed: 9 3 1 0 1 8
Y Y M M D D

Submitted by: David L. Dingman Phone #: (415) 872-5962

REGULATED ORGANIC CHEMICALS

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Bromodichloromethane	32101	ND		0.50
524.2	Bromoform	32104	ND		0.50
524.2	Chloroform (Trichloromethane)	32106	ND		0.50
524.2	Dibromochloromethane	32105	ND		0.50
524.2	Total Trihalomethanes (THM'S/TTHM)	82080	ND	100	0.50
524.2	Benzene	34030	ND	1	0.50
524.2	Carbon tetrachloride	32102	ND	.5	0.50
524.2	Ethyl benzene	34371	ND	**680	0.50
524.2	1,4-Dichlorobenzene (p-DCB)	34571	ND	5	0.50
524.2	1,1-Dichloroethane (1,1-DCA)	34496	ND	5	0.50
524.2	1,2-Dichloroethane (1,2-DCA)	34531	ND	.5	0.50
524.2	1,1-Dichloroethylene (1,1-DCE)	34501	ND	** 6	0.50
524.2	cis-1,2-Dichloroethylene	77093	ND	6	0.50
524.2	trans-1,2-Dichloroethylene	34546	ND	10	0.50
524.2	1,2-Dichloropropane	34541	ND	5	0.50
524.2	Total 1,3-Dichloropropene	34561	ND	.5	0.50
524.2	Monochlorobenzene (Chlorobenzene)	34301	ND	** 30	0.50
524.2	1,1,2,2-Tetrachloroethane	34516	ND	1	0.50
524.2	Tetrachloroethylene (PCE)	34475	ND	5	0.50
524.2	1,1,1-Trichloroethane (1,1,1-TCA)	34506	ND	200	0.50
524.2	1,1,2-Trichloroethane (1,1,2-TCA)	34511	ND	** 32	0.50
524.2	Trichloroethylene (TCE)	39180	ND	5	0.50

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Trichlorofluoromethane (Freon 11)	34488	ND	150	0.50
524.2	Trichlorotrifluoroethane (Freon 113)	81611	ND	1200	0.50
524.2	Vinyl chloride (VC)	39175	ND	.5	0.50
524.2	m,p-Xylene	A-014	ND		0.50
524.2	o-Xylene	77135	ND		0.50
524.2	Total Xylenes (m,p & o)	81551	ND	1750	0.50
	Dibromochloropropane (DBCP)	38761		.2	0.01
	Ethylene Dibromide (EDB)	77651		.02	0.01
	Endrin	39390		** .2	0.01
	Lindane (gamma-BHC)	39340		** 4	0.02
	Methoxychlor	39480		**100	0.1
	Toxaphene	39400		** 5	1.
	Chlordane	39350		.1	0.10
	Diethylhexylphthalate (DEHP)	39100		4	0.6
	Heptachlor	39410		.01	0.01
	Heptachlor epoxide	39420		.01	0.01
	Atrazine (AAtrex)	39033		3	0.1
	Molinate (Ordram)	82199		20	2.0
	Simazine (Princep)	39055		** 10	.07
	Thiobencarb (Bolero)	A-001		70	1.0
	Bentazon (Basagran)	38710		18	2.0
	2,4-D	39730		**100	0.1
	2,4,5-TP (Silvex)	39045		** 10	0.2
	Carbofuran (Furadan)	81405		18	0.9
	Glyphosate	79743		700	6.

UNREGULATED ORGANIC CHEMICALS

524.2	Bromobenzene	81555	ND		0.50
524.2	Bromochloromethane	A-012	ND		0.50
524.2	Bromomethane (Methyl Bromide)	34413	ND		0.50
524.2	n-Butylbenzene	A-010	ND		0.50
524.2	sec-Butylbenzene	77350	ND		0.50
524.2	tert-Butylbenzene	77353	ND		0.50
524.2	Chloroethane	34311	ND		0.50
524.2	2-Chloroethylvinyl ether	34576	ND		1.0
524.2	Chloromethane (Methyl Chloride)	34418	ND		0.50
524.2	2-Chlorotoluene	A-008	ND		0.50
524.2	4-Chlorotoluene	A-009	ND		0.50
524.2	Dibromomethane	77596	ND		0.50
524.2	1,2-Dichlorobenzene (o-DCB)	34536	ND	**	0.50
524.2	1,3-Dichlorobenzene (m-DCB)	34566	ND		0.50
524.2	Dichlorodifluoromethane	34668	ND		1.0
524.2	Dichloromethane (Methylene Chloride)	34423	ND	**	0.5
524.2	1,3-Dichloropropane	77173	ND		0.50
524.2	2,2-Dichloropropane	77170	ND		0.50
524.2	1,1-Dichloropropene	77168	ND		0.50
524.2	Hexachlorobutadiene	34391	ND		0.50
524.2	Isopropylbenzene (Cumene)	77223	ND		0.50
524.2	p-Isopropyltoluene	A-011	ND		0.50
524.2	Naphthalene	34696	ND		0.50
524.2	n-Propylbenzene	77224	ND		0.50
524.2	Styrene	77128	ND	**	0.50

ORGANIC CHEMICAL ANALYSES (3/93)

Date of Report: 940118 | Sample ID No.

Laboratory Name: San Francisco Water Dept. | Signature Lab Director:

Name of Sampler: D. Dingman | Employed By: San Francisco Water Dep

Date/Time Sample Collected: 9310130910 | Date/Time Sample Received @ Lab: 9310131315 | Date Analyses Completed: 931018

System Name: City of San Francisco | System Number: 3810001

Name or Number Of Sample Source: San Antonio Reservoir

User ID: E N G | Station Number: D 3 8 / 0 0 1 - A N T O N - R

Date/Time of Sample: 9 3 1 0 1 3 0 9 1 0 | Laboratory Code: 9 5 5 3
Y Y M M D D T T T T

Date Analyses Completed: 9 3 1 0 1 8
Y Y M M D D

Submitted by: David L. Dingman | Phone #: (415) 872-5962

REGULATED ORGANIC CHEMICALS

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Bromodichloromethane	32101	ND		0.50
524.2	Bromoform	32104	ND		0.50
524.2	Chloroform (Trichloromethane)	32106	ND		0.50
524.2	Dibromochloromethane	32105	ND		0.50
524.2	Total Trihalomethanes (THM'S/TTHM)	82080	ND	100	0.50
524.2	Benzene	34030	ND	1	0.50
524.2	Carbon tetrachloride	32102	ND	.5	0.50
524.2	Ethyl benzene	34371	ND	**680	0.50
524.2	1,4-Dichlorobenzene (p-DCB)	34571	ND	5	0.50
524.2	1,1-Dichloroethane (1,1-DCA)	34496	ND	5	0.50
524.2	1,2-Dichloroethane (1,2-DCA)	34531	ND	.5	0.50
524.2	1,1-Dichloroethylene (1,1-DCE)	34501	ND	** 6	0.50
524.2	cis-1,2-Dichloroethylene	77093	ND	6	0.50
524.2	trans-1,2-Dichloroethylene	34546	ND	10	0.50
524.2	1,2-Dichloropropane	34541	ND	5	0.50
524.2	Total 1,3-Dichloropropene	34561	ND	.5	0.50
524.2	Monochlorobenzene (Chlorobenzene)	34301	ND	** 30	0.50
524.2	1,1,2,2-Tetrachloroethane	34516	ND	1	0.50
524.2	Tetrachloroethylene (PCE)	34475	ND	5	0.50
524.2	1,1,1-Trichloroethane (1,1,1-TCA)	34506	ND	200	0.50
524.2	1,1,2-Trichloroethane (1,1,2-TCA)	34511	ND	** 32	0.50
524.2	Trichloroethylene (TCE)	39180	ND	5	0.50

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Trichlorofluoromethane (Freon 11)	34488	ND	150	0.50
524.2	Trichlorotrifluoroethane (Freon 113)	81611	ND	1200	0.50
524.2	Vinyl chloride (VC)	39175	ND	.5	0.50
524.2	m,p-Xylene	A-014	ND		0.50
524.2	o-Xylene	77135	ND		0.50
524.2	Total Xylenes (m,p & o)	81551	ND	1750	0.50
	Dibromochloropropane (DBCP)	38761		.2	0.01
	Ethylene Dibromide (EDB)	77651		.02	0.01
	Endrin	39390		** .2	0.01
	Lindane (gamma-BHC)	39340		** 4	0.02
	Methoxychlor	39480		**100	0.1
	Toxaphene	39400		** 5	1.
	Chlordane	39350		.1	0.10
	Diethylhexylphthalate (DEHP)	39100		4	0.6
	Heptachlor	39410		.01	0.01
	Heptachlor epoxide	39420		.01	0.01
	Atrazine (AAtrex)	39033		3	0.1
	Molinate (Ordram)	82199		20	2.0
	Simazine (Princep)	39055		** 10	.07
	Thiobencarb (Bolero)	A-001		70	1.0
	Bentazon (Basagran)	38710		18	2.0
	2,4-D	39730		**100	0.1
	2,4,5-TP (Silvex)	39045		** 10	0.2
	Carbofuran (Furadan)	81405		18	0.9
	Glyphosate	79743		700	6.

UNREGULATED ORGANIC CHEMICALS

TEST METHOD	CONSTITUENT	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Bromobenzene	81555	ND		0.50
524.2	Bromochloromethane	A-012	ND		0.50
524.2	Bromomethane (Methyl Bromide)	34413	ND		0.50
524.2	n-Butylbenzene	A-010	ND		0.50
524.2	sec-Butylbenzene	77350	ND		0.50
524.2	tert-Butylbenzene	77353	ND		0.50
524.2	Chloroethane	34311	ND		0.50
524.2	2-Chloroethylvinyl ether	34576	ND		1.0
524.2	Chloromethane (Methyl Chloride)	34418	ND		0.50
524.2	2-Chlorotoluene	A-008	ND		0.50
524.2	4-Chlorotoluene	A-009	ND		0.50
524.2	Dibromomethane	77596	ND		0.50
524.2	1,2-Dichlorobenzene (o-DCB)	34536	ND	**	0.50
524.2	1,3-Dichlorobenzene (m-DCB)	34566	ND		0.50
524.2	Dichlorodifluoromethane	34668	ND		1.0
524.2	Dichloromethane (Methylene Chloride)	34423	ND	**	0.5
524.2	1,3-Dichloropropane	77173	ND		0.50
524.2	2,2-Dichloropropane	77170	ND		0.50
524.2	1,1-Dichloropropene	77168	ND		0.50
524.2	Hexachlorobutadiene	34391	ND		0.50
524.2	Isopropylbenzene (Cumene)	77223	ND		0.50
524.2	p-Isopropyltoluene	A-011	ND		0.50
524.2	Naphthalene	34696	ND		0.50
524.2	n-Propylbenzene	77224	ND		0.50
524.2	Styrene	77128	ND	**	0.50

ORGANIC CHEMICAL ANALYSES (3/93)

Date of Report: 940215 Sample ID No. ________

Laboratory Name: San Francisco Water Dept. Signature Lab Director: [signature]

Name of Sampler: L. Chan Employed By: San Francisco Water Dep

Date/Time Sample Collected: 9402091225 Date/Time Sample Received @ Lab: 9402091330 Date Analyses Completed: 940210

System Name: City of San Francisco System Number: 3810001

Name or Number Of Sample Source: Lower Crystal Springs Reservoir

User ID: E N G Station Number: D 3 8 / 0 0 1 - L C S - R

Date/Time of Sample: 9 4 0 2 0 9 1 2 2 5 Laboratory Code: 9 5 5 3
Y Y M M D D T T T T

Date Analyses Completed: 9 4 0 2 1 0
Y Y M M D D

Submitted by: David L. Dingman Phone #: (415) 872-5962

REGULATED ORGANIC CHEMICALS

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Bromodichloromethane	32101	ND		0.50
524.2	Bromoform	32104	ND		0.50
524.2	Chloroform (Trichloromethane)	32106	ND		0.50
524.2	Dibromochloromethane	32105	ND		0.50
524.2	Total Trihalomethanes (THM'S/TTHM)	82080	ND	100	0.50
524.2	Benzene	34030	ND	1	0.50
524.2	Carbon tetrachloride	32102	ND	.5	0.50
524.2	Ethyl benzene	34371	ND	**680	0.50
524.2	1,4-Dichlorobenzene (p-DCB)	34571	ND	5	0.50
524.2	1,1-Dichloroethane (1,1-DCA)	34496	ND	5	0.50
524.2	1,2-Dichloroethane (1,2-DCA)	34531	ND	.5	0.50
524.2	1,1-Dichloroethylene (1,1-DCE)	34501	ND	** 6	0.50
524.2	cis-1,2-Dichloroethylene	77093	ND	6	0.50
524.2	trans-1,2-Dichloroethylene	34546	ND	10	0.50
524.2	1,2-Dichloropropane	34541	ND	5	0.50
524.2	Total 1,3-Dichloropropene	34561	ND	.5	0.50
524.2	Monochlorobenzene (Chlorobenzene)	34301	ND	** 30	0.50
524.2	1,1,2,2-Tetrachloroethane	34516	ND	1	0.50
524.2	Tetrachloroethylene (PCE)	34475	ND	5	0.50
524.2	1,1,1-Trichloroethane (1,1,1-TCA)	34506	ND	200	0.50
524.2	1,1,2-Trichloroethane (1,1,2-TCA)	34511	ND	** 32	0.50
524.2	Trichloroethylene (TCE)	39180	ND	5	0.50

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Trichlorofluoromethane (Freon 11)	34488	ND	150	0.50
524.2	Trichlorotrifluoroethane (Freon 113)	81611	ND	1200	0.50
524.2	Vinyl chloride (VC)	39175	ND	.5	0.50
524.2	m,p-Xylene	A-014	ND		0.50
524.2	o-Xylene	77135	ND		0.50
524.2	Total Xylenes (m,p & o)	81551	ND	1750	0.50

	Dibromochloropropane (DBCP)	38761		.2	0.01
	Ethylene Dibromide (EDB)	77651		.02	0.01
	Endrin	39390		** .2	0.01
	Lindane (gamma-BHC)	39340		** 4	0.02
	Methoxychlor	39480		**100	0.1
	Toxaphene	39400		** 5	1.
	Chlordane	39350		.1	0.10
	Diethylhexylphthalate (DEHP)	39100		4	0.6
	Heptachlor	39410		.01	0.01
	Heptachlor epoxide	39420		.01	0.01
	Atrazine (AAtrex)	39033		3	0.1
	Molinate (Ordram)	82199		20	2.0
	Simazine (Princep)	39055		** 10	.07
	Thiobencarb (Bolero)	A-001		70	1.0
	Bentazon (Basagran)	38710		18	2.0
	2,4-D	39730		**100	0.1
	2,4,5-TP (Silvex)	39045		** 10	0.2
	Carbofuran (Furadan)	81405		18	0.9
	Glyphosate	79743		700	6.

UNREGULATED ORGANIC CHEMICALS

524.2	Bromobenzene	81555	ND		0.50
524.2	Bromochloromethane	A-012	ND		0.50
24.2	Bromomethane (Methyl Bromide)	34413	ND		0.50
524.2	n-Butylbenzene	A-010	ND		0.50
524.2	sec-Butylbenzene	77350	ND		0.50
24.2	tert-Butylbenzene	77353	ND		0.50
24.2	Chloroethane	34311	ND		0.50
524.2	2-Chloroethylvinyl ether	34576	ND		1.0
24.2	Chloromethane (Methyl Chloride)	34418	ND		0.50
24.2	2-Chlorotoluene	A-008	ND		0.50
524.2	4-Chlorotoluene	A-009	ND		0.50
524.2	Dibromomethane	77596	ND		0.50
24.2	1,2-Dichlorobenzene (o-DCB)	34536	ND	**	0.50
524.2	1,3-Dichlorobenzene (m-DCB)	34566	ND		0.50
524.2	Dichlorodifluoromethane	34668	ND		1.0
24.2	Dichloromethane (Methylene Chloride)	34423	ND	**	0.5
524.2	1,3-Dichloropropane	77173	ND		0.50
524.2	2,2-Dichloropropane	77170	ND		0.50
24.2	1,1-Dichloropropene	77168	ND		0.50
24.2	Hexachlorobutadiene	34391	ND		0.50
524.2	Isopropylbenzene (Cumene)	77223	ND		0.50
24.2	p-Isopropyltoluene	A-011	ND		0.50
24.2	Naphthalene	34696	ND		0.50
524.2	n-Propylbenzene	77224	ND		0.50
524.2	Styrene	77128	ND	**	0.50

ORGANIC CHEMICAL ANALYSES (3/93)

Date of Report: 940118 Sample ID No.

Laboratory Name: San Francisco Water Dept. Signature Lab Director:

Name of Sampler: G. Kazarian Employed By: San Francisco Water Dep

Date/Time Sample Collected: 9310130915 Date/Time Sample Received @ Lab: 9310131350 Date Analyses Completed: 931018

System Name: City of San Francisco System Number: 3810001

Name or Number Of Sample Source: Lower Crystal Springs Reservoir

User ID: E N G Station Number: D 3 8 / 0 0 1 - L C S - R

Date/Time of Sample: 9 3 1 0 1 3 0 9 1 5 (Y Y M M D D T T T T) Laboratory Code: 9 5 5 3

Date Analyses Completed: 9 3 1 0 1 8 (Y Y M M D D)

Submitted by: David L. Dingman Phone #: (415) 872-5962

REGULATED ORGANIC CHEMICALS

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Bromodichloromethane	32101	ND		0.50
524.2	Bromoform	32104	ND		0.50
524.2	Chloroform (Trichloromethane)	32106	0.8		0.50
524.2	Dibromochloromethane	32105	ND		0.50
524.2	Total Trihalomethanes (THM'S/TTHM)	82080	ND	100	0.50
524.2	Benzene	34030	ND	1	0.50
524.2	Carbon tetrachloride	32102	ND	.5	0.50
524.2	Ethyl benzene	34371	ND	**680	0.50
524.2	1,4-Dichlorobenzene (p-DCB)	34571	ND	5	0.50
524.2	1,1-Dichloroethane (1,1-DCA)	34496	ND	5	0.50
524.2	1,2-Dichloroethane (1,2-DCA)	34531	ND	.5	0.50
524.2	1,1-Dichloroethylene (1,1-DCE)	34501	ND	** 6	0.50
524.2	cis-1,2-Dichloroethylene	77093	ND	6	0.50
524.2	trans-1,2-Dichloroethylene	34546	ND	10	0.50
524.2	1,2-Dichloropropane	34541	ND	5	0.50
524.2	Total 1,3-Dichloropropene	34561	ND	.5	0.50
524.2	Monochlorobenzene (Chlorobenzene)	34301	ND	** 30	0.50
524.2	1,1,2,2-Tetrachloroethane	34516	ND	1	0.50
524.2	Tetrachloroethylene (PCE)	34475	ND	5	0.50
524.2	1,1,1-Trichloroethane (1,1,1-TCA)	34506	ND	200	0.50
524.2	1,1,2-Trichloroethane (1,1,2-TCA)	34511	ND	** 32	0.50
524.2	Trichloroethylene (TCE)	39180	ND	5	0.50

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Trichlorofluoromethane (Freon 11)	34488	ND	150	0.50
524.2	Trichlorotrifluoroethane (Freon 113)	81611	ND	1200	0.50
524.2	Vinyl chloride (VC)	39175	ND	.5	0.50
524.2	m,p-Xylene	A-014	ND		0.50
524.2	o-Xylene	77135	ND		0.50
524.2	Total Xylenes (m,p & o)	81551	ND	1750	0.50
	Dibromochloropropane (DBCP)	38761		.2	0.01
	Ethylene Dibromide (EDB)	77651		.02	0.01
	Endrin	39390		** .2	0.01
	Lindane (gamma-BHC)	39340		** 4	0.02
	Methoxychlor	39480		**100	0.1
	Toxaphene	39400		** 5	1.
	Chlordane	39350		.1	0.10
	Diethylhexylphthalate (DEHP)	39100		4	0.6
	Heptachlor	39410		.01	0.01
	Heptachlor epoxide	39420		.01	0.01
	Atrazine (AAtrex)	39033		3	0.1
	Molinate (Ordram)	82199		20	2.0
	Simazine (Princep)	39055		** 10	.07
	Thiobencarb (Bolero)	A-001		70	1.0
	Bentazon (Basagran)	38710		18	2.0
	2,4-D	39730		**100	0.1
	2,4,5-TP (Silvex)	39045		** 10	0.2
	Carbofuran (Furadan)	81405		18	0.9
	Glyphosate	79743		700	6.

UNREGULATED ORGANIC CHEMICALS

TEST METHOD	CONSTITUENT	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Bromobenzene	81555	ND		0.50
524.2	Bromochloromethane	A-012	ND		0.50
524.2	Bromomethane (Methyl Bromide)	34413	ND		0.50
524.2	n-Butylbenzene	A-010	ND		0.50
524.2	sec-Butylbenzene	77350	ND		0.50
524.2	tert-Butylbenzene	77353	ND		0.50
524.2	Chloroethane	34311	ND		0.50
524.2	2-Chloroethylvinyl ether	34576	ND		1.0
524.2	Chloromethane (Methyl Chloride)	34418	ND		0.50
524.2	2-Chlorotoluene	A-008	ND		0.50
524.2	4-Chlorotoluene	A-009	ND		0.50
524.2	Dibromomethane	77596	ND		0.50
524.2	1,2-Dichlorobenzene (o-DCB)	34536	ND	**	0.50
524.2	1,3-Dichlorobenzene (m-DCB)	34566	ND		0.50
524.2	Dichlorodifluoromethane	34668	ND		1.0
524.2	Dichloromethane (Methylene Chloride)	34423	ND	**	0.5
524.2	1,3-Dichloropropane	77173	ND		0.50
524.2	2,2-Dichloropropane	77170	ND		0.50
524.2	1,1-Dichloropropene	77168	ND		0.50
524.2	Hexachlorobutadiene	34391	ND		0.50
524.2	Isopropylbenzene (Cumene)	77223	ND		0.50
524.2	p-Isopropyltoluene	A-011	ND		0.50
524.2	Naphthalene	34696	ND		0.50
524.2	n-Propylbenzene	77224	ND		0.50
524.2	Styrene	77128	ND	**	0.50

ORGANIC CHEMICAL ANALYSES (3/93)

Date of Report: 940118 Sample ID No. ________

Laboratory Name: San Francisco Water Dept. Signature Lab Director: [signature]

Name of Sampler: G. Kazarian Employed By: San Francisco Water Dep

Date/Time Sample Collected: 9310131015 Date/Time Sample Received @ Lab: 9310131350 Date Analyses Completed: 931018

System Name: City of San Francisco System Number: 3810001

Name or Number Of Sample Source: Pilarcitos

User ID: E N G Station Number: D 3 8 / 0 0 1 - P I L A R - R

Date/Time of Sample: 9 3 1 0 1 3 1 0 1 5 (Y Y M M D D T T T T) Laboratory Code: 9 5 5 3

Date Analyses Completed: 9 3 1 0 1 8 (Y Y M M D D)

Submitted by: David L. Dingman Phone #: (415) 872-5962

REGULATED ORGANIC CHEMICALS

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Bromodichloromethane	32101	ND		0.50
524.2	Bromoform	32104	ND		0.50
524.2	Chloroform (Trichloromethane)	32106	ND		0.50
524.2	Dibromochloromethane	32105	ND		0.50
524.2	Total Trihalomethanes (THM'S/TTHM)	82080	ND	100	0.50
524.2	Benzene	34030	ND	1	0.50
524.2	Carbon tetrachloride	32102	ND	.5	0.50
524.2	Ethyl benzene	34371	ND	**680	0.50
524.2	1,4-Dichlorobenzene (p-DCB)	34571	ND	5	0.50
524.2	1,1-Dichloroethane (1,1-DCA)	34496	ND	5	0.50
524.2	1,2-Dichloroethane (1,2-DCA)	34531	ND	.5	0.50
524.2	1,1-Dichloroethylene (1,1-DCE)	34501	ND	** 6	0.50
524.2	cis-1,2-Dichloroethylene	77093	ND	6	0.50
524.2	trans-1,2-Dichloroethylene	34546	ND	10	0.50
524.2	1,2-Dichloropropane	34541	ND	5	0.50
524.2	Total 1,3-Dichloropropene	34561	ND	.5	0.50
524.2	Monochlorobenzene (Chlorobenzene)	34301	ND	** 30	0.50
524.2	1,1,2,2-Tetrachloroethane	34516	ND	1	0.50
524.2	Tetrachloroethylene (PCE)	34475	ND	5	0.50
524.2	1,1,1-Trichloroethane (1,1,1-TCA)	34506	ND	200	0.50
524.2	1,1,2-Trichloroethane (1,1,2-TCA)	34511	ND	** 32	0.50
524.2	Trichloroethylene (TCE)	39180	ND	5	0.50

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Trichlorofluoromethane (Freon 11)	34488	ND	150	0.50
524.2	Trichlorotrifluoroethane (Freon 113)	81611	ND	1200	0.50
524.2	Vinyl chloride (VC)	39175	ND	.5	0.50
524.2	m,p-Xylene	A-014	ND		0.50
524.2	o-Xylene	77135	ND		0.50
524.2	Total Xylenes (m,p & o)	81551	ND	1750	0.50

	Dibromochloropropane (DBCP)	38761		.2	0.01
	Ethylene Dibromide (EDB)	77651		.02	0.01
	Endrin	39390		** .2	0.01
	Lindane (gamma-BHC)	39340		** 4	0.02
	Methoxychlor	39480		**100	0.1
	Toxaphene	39400		** 5	1.
	Chlordane	39350		.1	0.10
	Diethylhexylphthalate (DEHP)	39100		4	0.6
	Heptachlor	39410		.01	0.01
	Heptachlor epoxide	39420		.01	0.01
	Atrazine (AAtrex)	39033		3	0.1
	Molinate (Ordram)	82199		20	2.0
	Simazine (Princep)	39055		** 10	.07
	Thiobencarb (Bolero)	A-001		70	1.0
	Bentazon (Basagran)	38710		18	2.0
	2,4-D	39730		**100	0.1
	2,4,5-TP (Silvex)	39045		** 10	0.2
	Carbofuran (Furadan)	81405		18	0.9
	Glyphosate	79743		700	6.

UNREGULATED ORGANIC CHEMICALS

524.2	Bromobenzene	81555	ND		0.50
524.2	Bromochloromethane	A-012	ND		0.50
524.2	Bromomethane (Methyl Bromide)	34413	ND		0.50
524.2	n-Butylbenzene	A-010	ND		0.50
524.2	sec-Butylbenzene	77350	ND		0.50
524.2	tert-Butylbenzene	77353	ND		0.50
524.2	Chloroethane	34311	ND		0.50
524.2	2-Chloroethylvinyl ether	34576	ND		1.0
524.2	Chloromethane (Methyl Chloride)	34418	ND		0.50
524.2	2-Chlorotoluene	A-008	ND		0.50
524.2	4-Chlorotoluene	A-009	ND		0.50
524.2	Dibromomethane	77596	ND		0.50
524.2	1,2-Dichlorobenzene (o-DCB)	34536	ND	**	0.50
524.2	1,3-Dichlorobenzene (m-DCB)	34566	ND		0.50
524.2	Dichlorodifluoromethane	34668	ND		1.0
524.2	Dichloromethane (Methylene Chloride)	34423	ND	**	0.5
524.2	1,3-Dichloropropane	77173	ND		0.50
524.2	2,2-Dichloropropane	77170	ND		0.50
524.2	1,1-Dichloropropene	77168	ND		0.50
524.2	Hexachlorobutadiene	34391	ND		0.50
524.2	Isopropylbenzene (Cumene)	77223	ND		0.50
24.2	p-Isopropyltoluene	A-011	ND		0.50
524.2	Naphthalene	34696	ND		0.50
524.2	n-Propylbenzene	77224	ND		0.50
24.2	Styrene	77128	ND	**	0.50

ORGANIC CHEMICAL ANALYSES (3/93)

Date of Report: ______ Sample ID No. ______

Laboratory Name: San Francisco Water Dept. Signature Lab Director: [signature]

Name of Sampler: G. Kazarian Employed By: San Francisco Water Dep

Date/Time Sample Collected: 9310130945 Date/Time Sample Received @ Lab: 9310131350 Date Analyses Completed: 931018

System Name: City of San Francisco System Number: 3810001

Name or Number Of Sample Source: San Andreas Reservoir

User ID: E N G Station Number: D 3 8 / 0 0 1 - A N D R E - R

Date/Time of Sample: 9 3 1 0 1 3 0 9 4 5 (Y Y M M D D T T T T) Laboratory Code: 9 5 5 3

Date Analyses Completed: 9 3 1 0 1 8 (Y Y M M D D)

Submitted by: David L. Dingman Phone #: (415) 872-5962

REGULATED ORGANIC CHEMICALS

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
524.2	Bromodichloromethane	32101	ND		0.50
524.2	Bromoform	32104	ND		0.50
524.2	Chloroform (Trichloromethane)	32106	ND		0.50
524.2	Dibromochloromethane	32105	ND		0.50
524.2	Total Trihalomethanes (THM'S/TTHM)	82080	ND	100	0.50
524.2	Benzene	34030	ND	1	0.50
524.2	Carbon tetrachloride	32102	ND	.5	0.50
524.2	Ethyl benzene	34371	ND	**680	0.50
524.2	1,4-Dichlorobenzene (p-DCB)	34571	ND	5	0.50
524.2	1,1-Dichloroethane (1,1-DCA)	34496	ND	5	0.50
524.2	1,2-Dichloroethane (1,2-DCA)	34531	ND	.5	0.50
524.2	1,1-Dichloroethylene (1,1-DCE)	34501	ND	** 6	0.50
524.2	cis-1,2-Dichloroethylene	77093	ND	6	0.50
524.2	trans-1,2-Dichloroethylene	34546	ND	10	0.50
524.2	1,2-Dichloropropane	34541	ND	5	0.50
524.2	Total 1,3-Dichloropropene	34561	ND	.5	0.50
524.2	Monochlorobenzene (Chlorobenzene)	34301	ND	** 30	0.50
524.2	1,1,2,2-Tetrachloroethane	34516	ND	1	0.50
524.2	Tetrachloroethylene (PCE)	34475	ND	5	0.50
524.2	1,1,1-Trichloroethane (1,1,1-TCA)	34506	ND	200	0.50
524.2	1,1,2-Trichloroethane (1,1,2-TCA)	34511	ND	** 32	0.50
524.2	Trichloroethylene (TCE)	39180	ND	5	0.50

TEST METHOD	CONSTITUENT ALL CONSTITUENTS REPORTED ug/L	ENTRY #	ANALYSES RESULTS	MCL ug/L	DLR ug/L
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524.2	o-Xylene	77135	ND		0.50
524.2	Total Xylenes (m,p & o)	81551	ND	1750	0.50
	Dibromochloropropane (DBCP)	38761		.2	0.01
	Ethylene Dibromide (EDB)	77651		.02	0.01
	Endrin	39390		** .2	0.01
	Lindane (gamma-BHC)	39340		** 4	0.02
	Methoxychlor	39480		**100	0.1
	Toxaphene	39400		** 5	1.
	Chlordane	39350		.1	0.10
	Diethylhexylphthalate (DEHP)	39100		4	0.6
	Heptachlor	39410		.01	0.01
	Heptachlor epoxide	39420		.01	0.01
	Atrazine (AAtrex)	39033		3	0.1
	Molinate (Ordram)	82199		20	2.0
	Simazine (Princep)	39055		** 10	.07
	Thiobencarb (Bolero)	A-001		70	1.0
	Bentazon (Basagran)	38710		18	2.0
	2,4-D	39730		**100	0.1
	2,4,5-TP (Silvex)	39045		** 10	0.2
	Carbofuran (Furadan)	81405		18	0.9
	Glyphosate	79743		700	6.

UNREGULATED ORGANIC CHEMICALS

524.2	Bromobenzene	81555	ND		0.50
524.2	Bromochloromethane	A-012	ND		0.50
524.2	Bromomethane (Methyl Bromide)	34413	ND		0.50
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524.2	sec-Butylbenzene	77350	ND		0.50
524.2	tert-Butylbenzene	77353	ND		0.50
524.2	Chloroethane	34311	ND		0.50
524.2	2-Chloroethylvinyl ether	34576	ND		1.0
524.2	Chloromethane (Methyl Chloride)	34418	ND		0.50
524.2	2-Chlorotoluene	A-008	ND		0.50
524.2	4-Chlorotoluene	A-009	ND		0.50
524.2	Dibromomethane	77596	ND		0.50
524.2	1,2-Dichlorobenzene (o-DCB)	34536	ND	**	0.50
524.2	1,3-Dichlorobenzene (m-DCB)	34566	ND		0.50
524.2	Dichlorodifluoromethane	34668	ND		1.0
524.2	Dichloromethane (Methylene Chloride)	34423	ND	**	0.5
524.2	1,3-Dichloropropane	77173	ND		0.50
524.2	2,2-Dichloropropane	77170	ND		0.50
524.2	1,1-Dichloropropene	77168	ND		0.50
524.2	Hexachlorobutadiene	34391	ND		0.50
524.2	Isopropylbenzene (Cumene)	77223	ND		0.50
524.2	p-Isopropyltoluene	A-011	ND		0.50
524.2	Naphthalene	34696	ND		0.50
524.2	n-Propylbenzene	77224	ND		0.50
524.2	Styrene	77128	ND	**	0.50

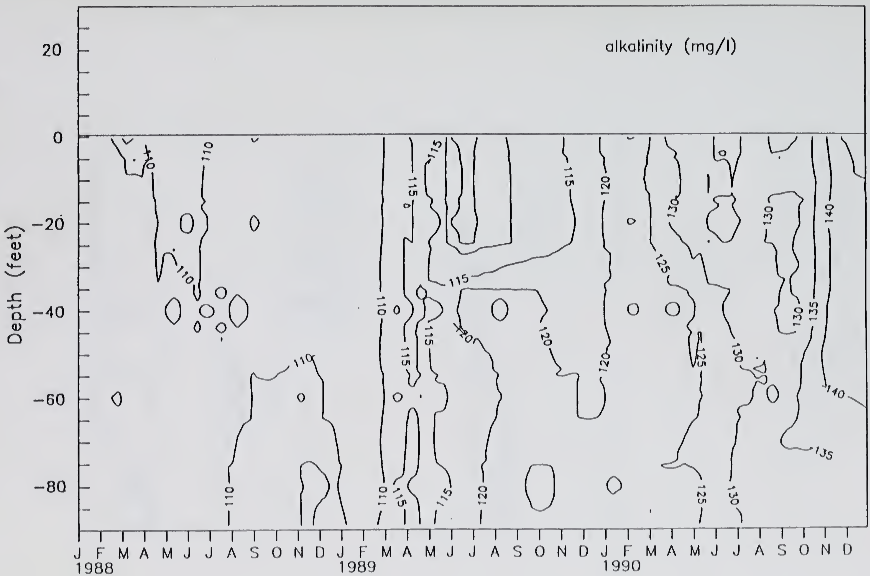
APPENDIX C

LIMNOLOGY WATER QUALITY DEPTH PROFILES AND ISOPLETHS

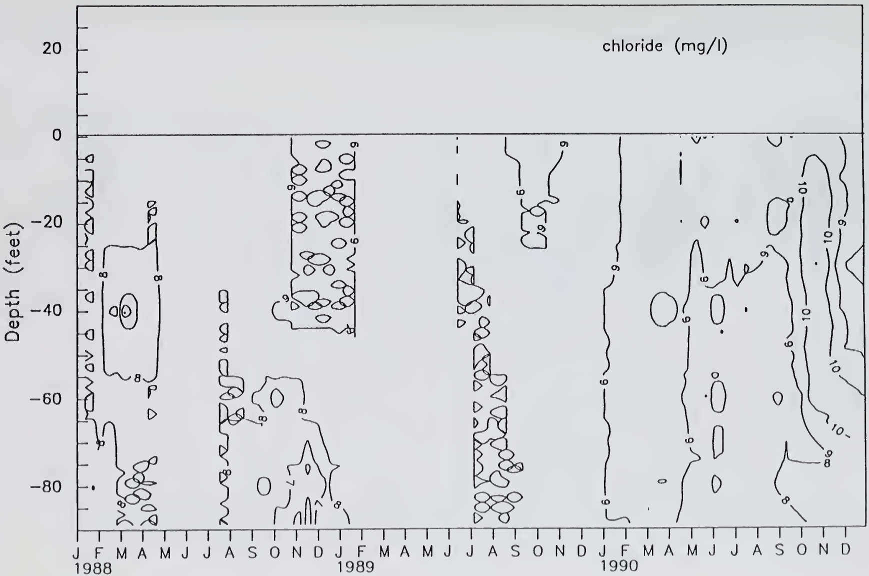
LIMNOLOGY WATER QUALITY
DEPTH PROFILES AND ISOPLETHS

CALAVERAS RESERVOIR

Calaveras


alkalinity (mg/l)
Depth (feet)
20
0
-20
-40
-60
-80
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990
110
115
120
125
130
135
140

Calaveras


chloride (mg/l)
Depth (feet)
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0
-20
-40
-60
-80
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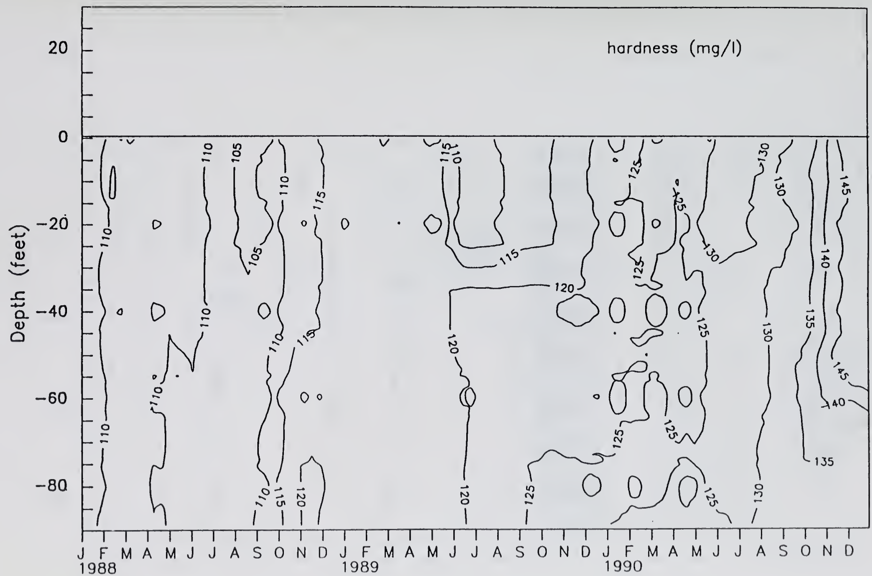
1988
1989
1990

Calaveras


hardness (mg/l)
Depth (feet)
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0
-20
-40
-60
-80
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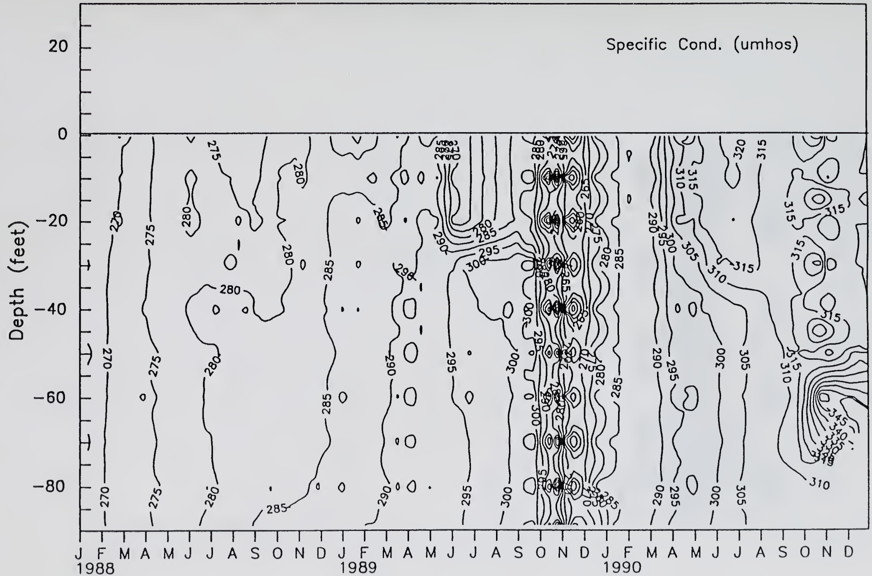
1988
1989
1990

Calaveras



Specific Cond. (umhos)
Depth (feet)
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0
-20
-40
-60
-80
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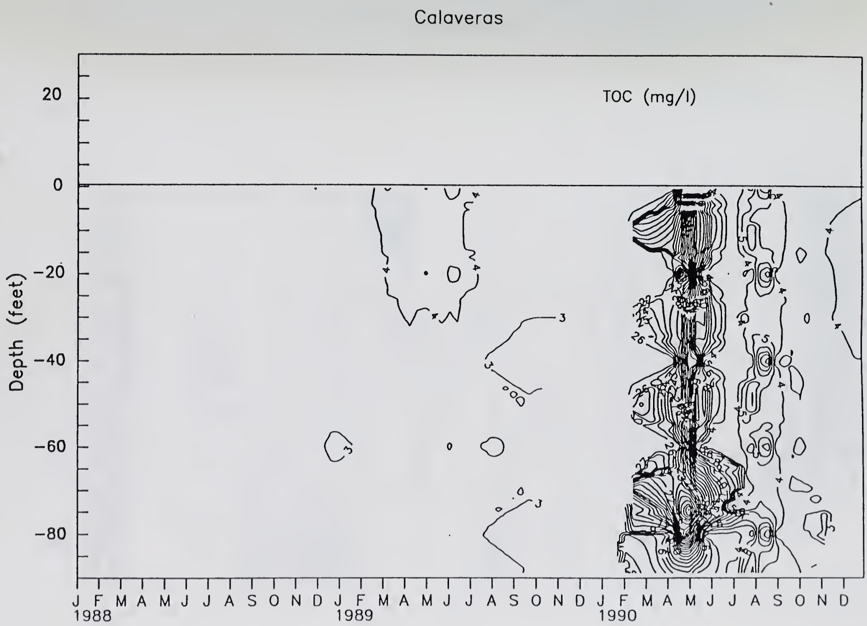
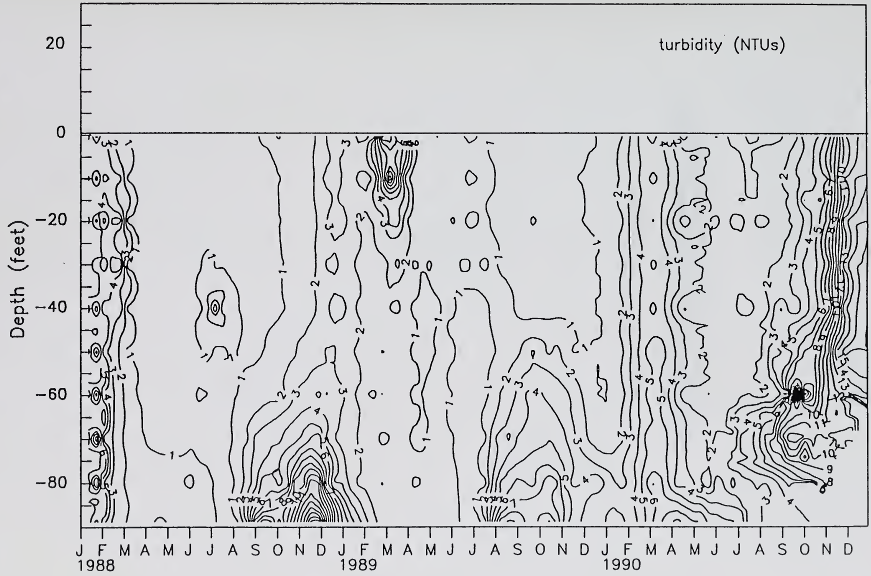
1988
1989
1990



Calaveras
TOC (mg/l)
Depth (feet)
20
0
-20
-40
-60
-80
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990

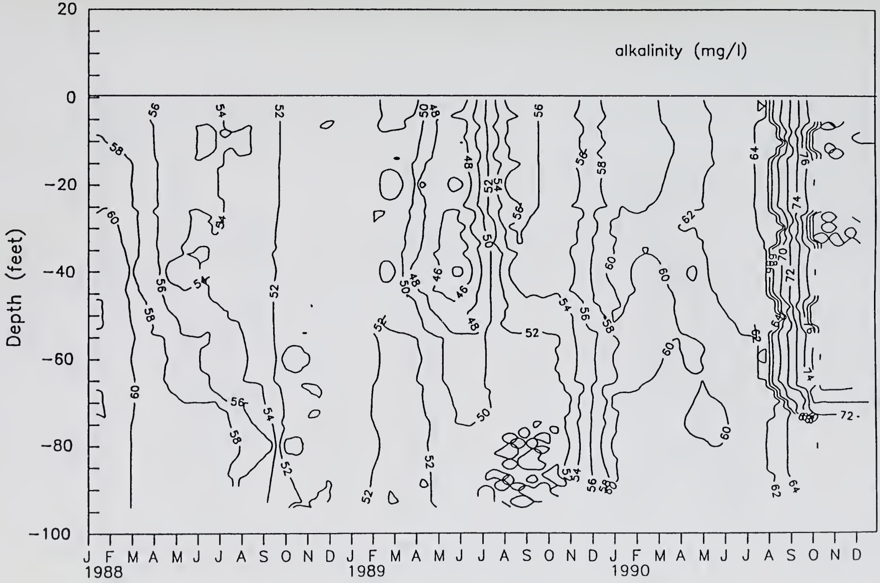
Calaveras


turbidity (NTUs)
Depth (feet)
20
0
-20
-40
-60
-80
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990

LIMNOLOGY WATER QUALITY
DEPTH PROFILES AND ISOPLETHS

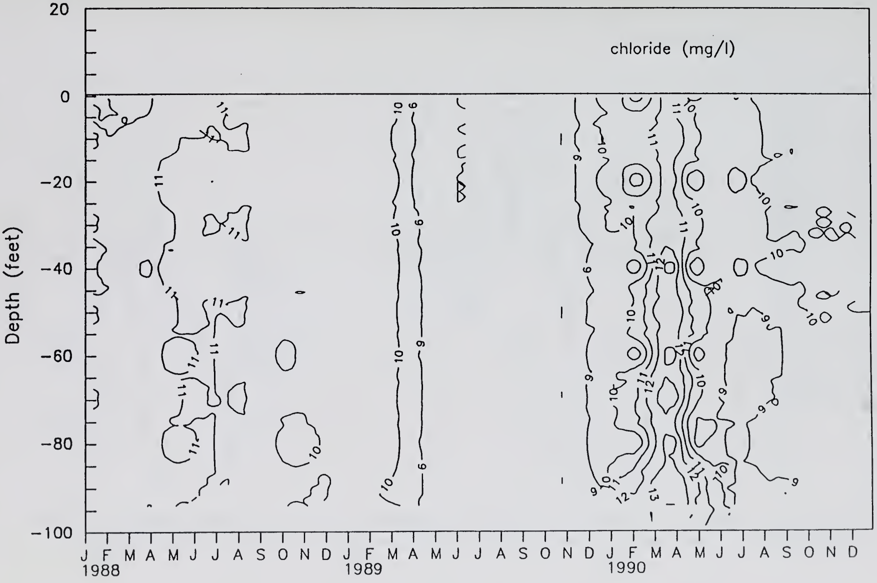
SAN ANTONIO RESERVOIR

San Antonio



alkalinity (mg/l)
Depth (feet)
20
0
-20
-40
-60
-80
-100
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990

San Antonio



chloride (mg/l)
Depth (feet)
20
0
-20
-40
-60
-80
-100
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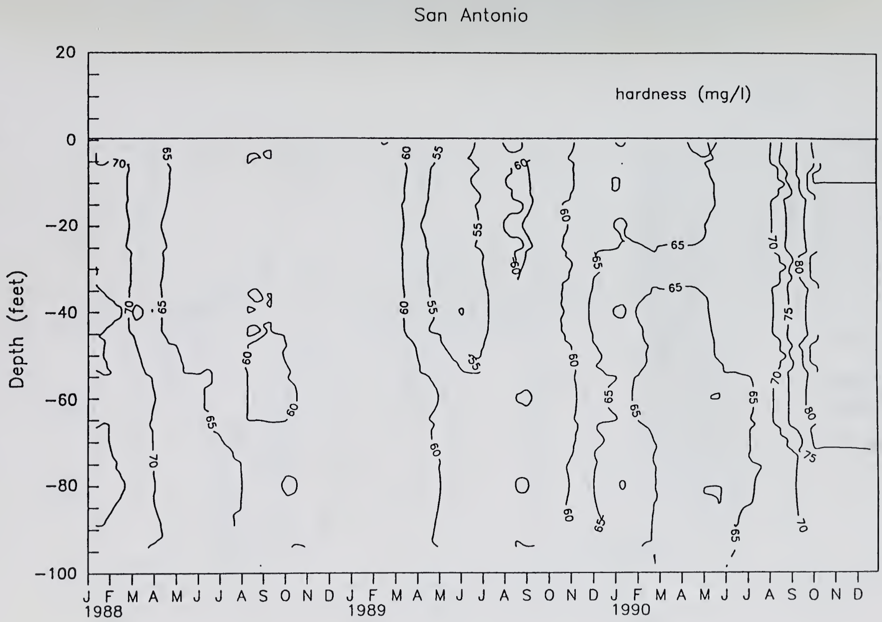
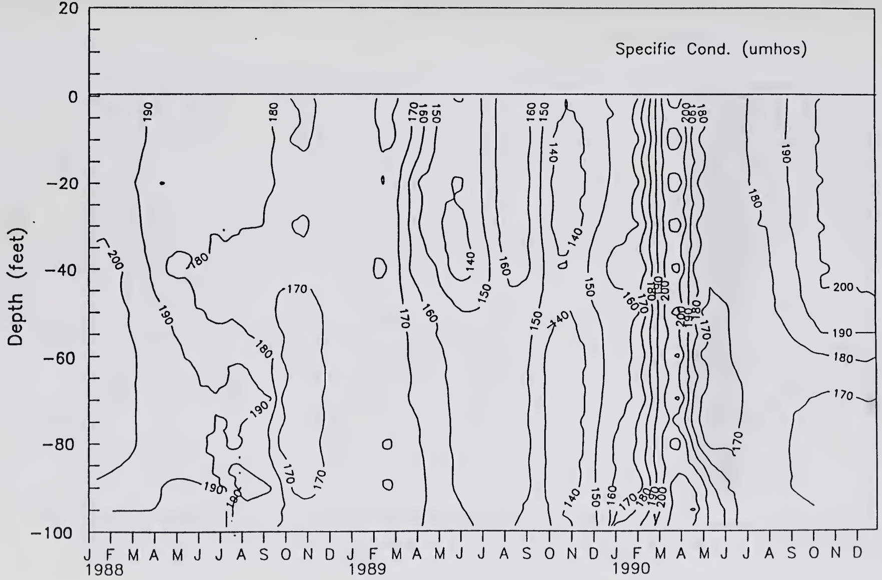
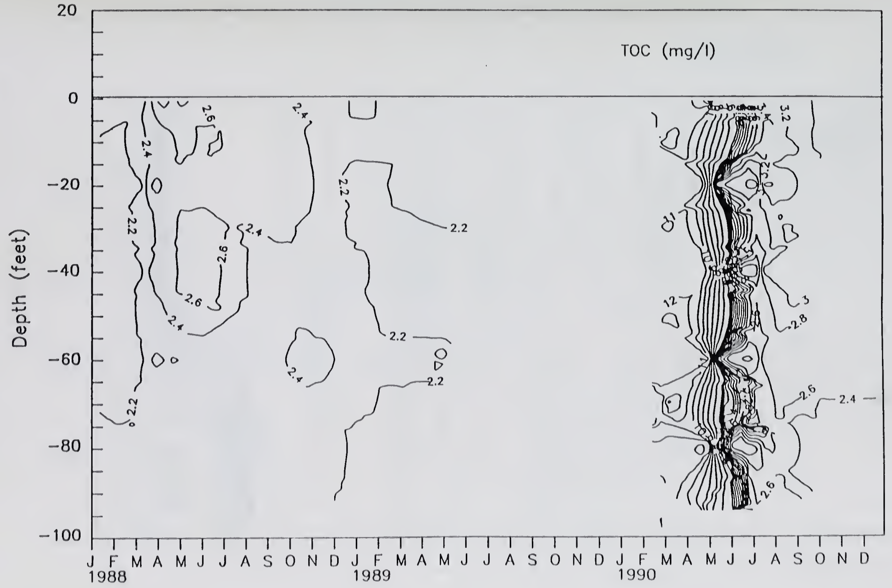
1988
1989
1990


San Antonio
hardness (mg/l)
Depth (feet)
20
0
−20
−40
−60
−80
−100
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990
70
65
60
55
75
80

San Antonio

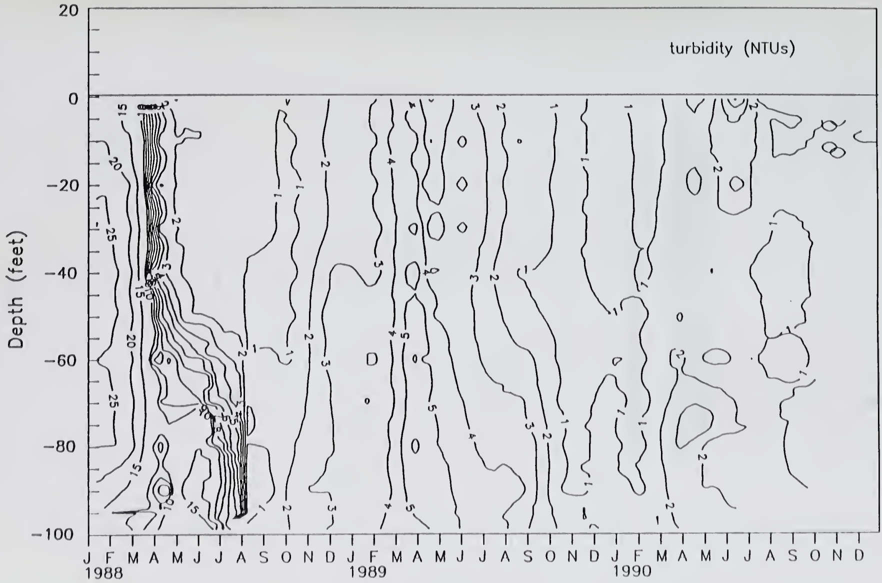

Specific Cond. (umhos)
Depth (feet)
20
0
-20
-40
-60
-80
-100
J F M A M J J A S O N D
1988
J F M A M J J A S O N D
1989
J F M A M J J A S O N D
1990

San Antonio



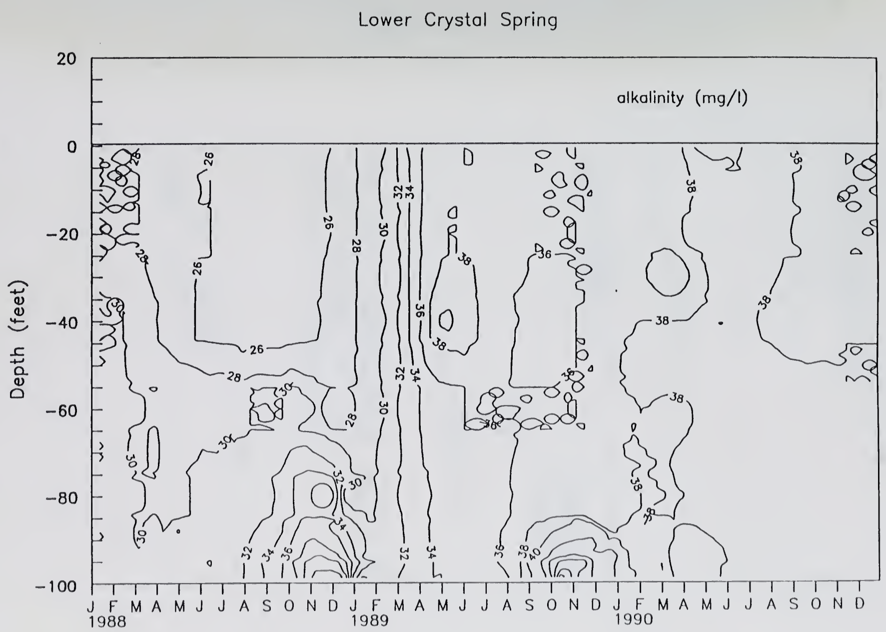
TOC (mg/l)
Depth (feet)
20
0
-20
-40
-60
-80
-100
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990
2.2
2.4
2.6
2.8
3
3.2

San Antonio

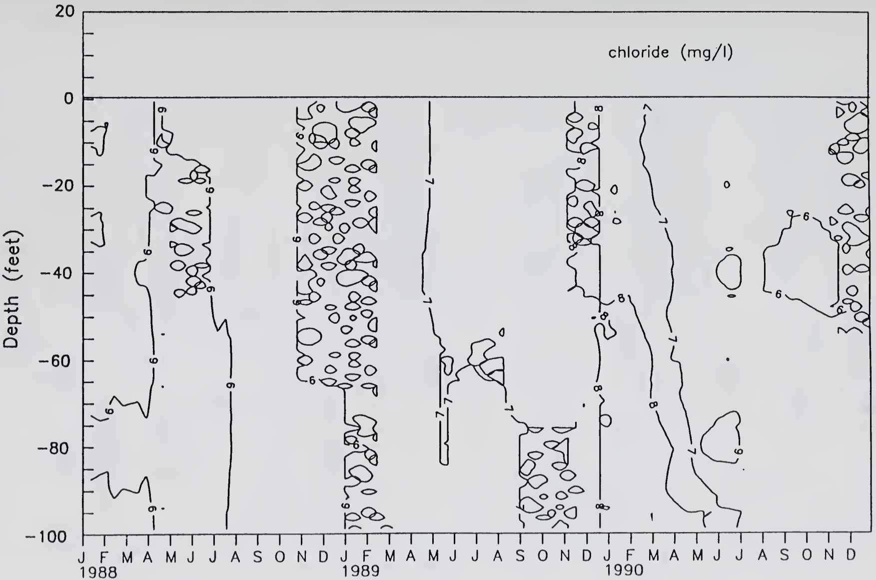

turbidity (NTUs)
Depth (feet)
20
0
-20
-40
-60
-80
-100
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990

LIMNOLOGY WATER QUALITY
DEPTH PROFILES AND ISOPLETHS

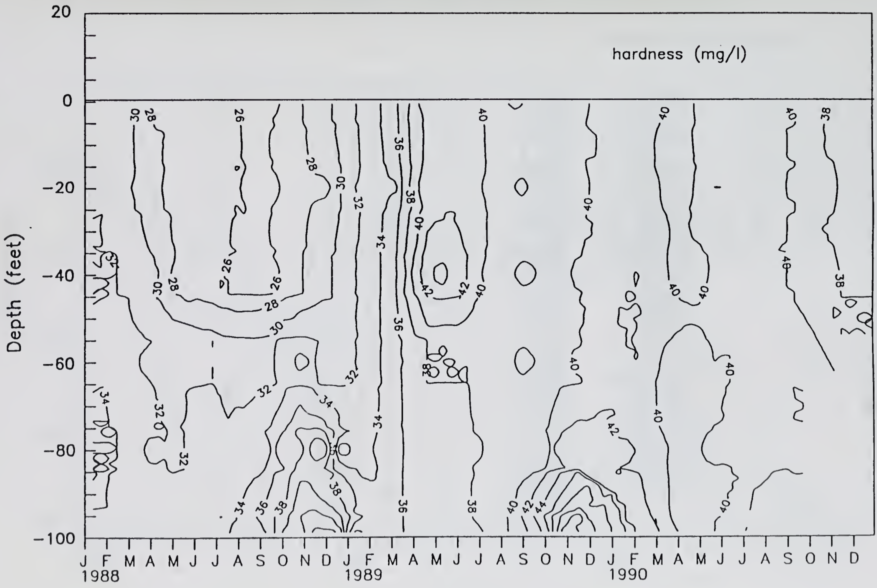
CRYSTAL SPRINGS RESERVOIR


Lower Crystal Spring
alkalinity (mg/l)
Depth (feet)
20
0
-20
-40
-60
-80
-100
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990
26
28
30
32
34
36
38
40

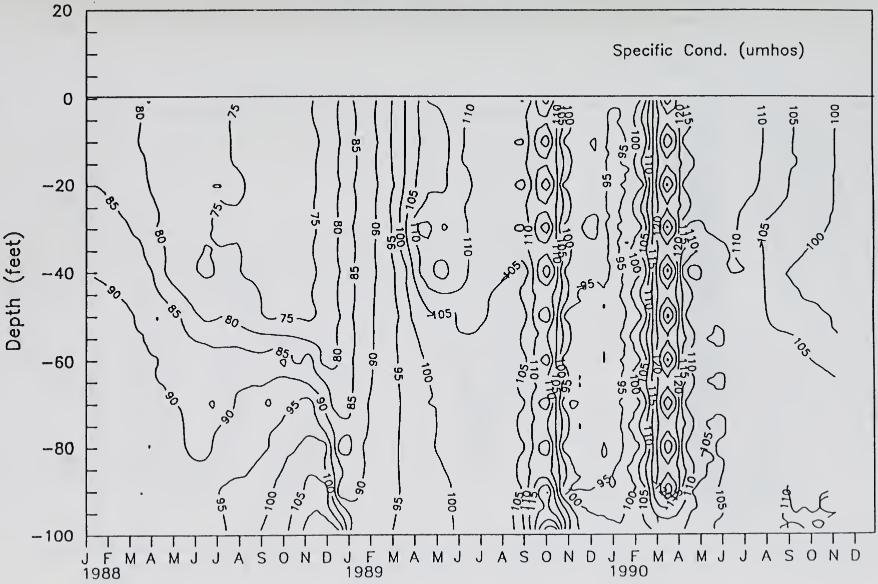
Lower Crystal Spring



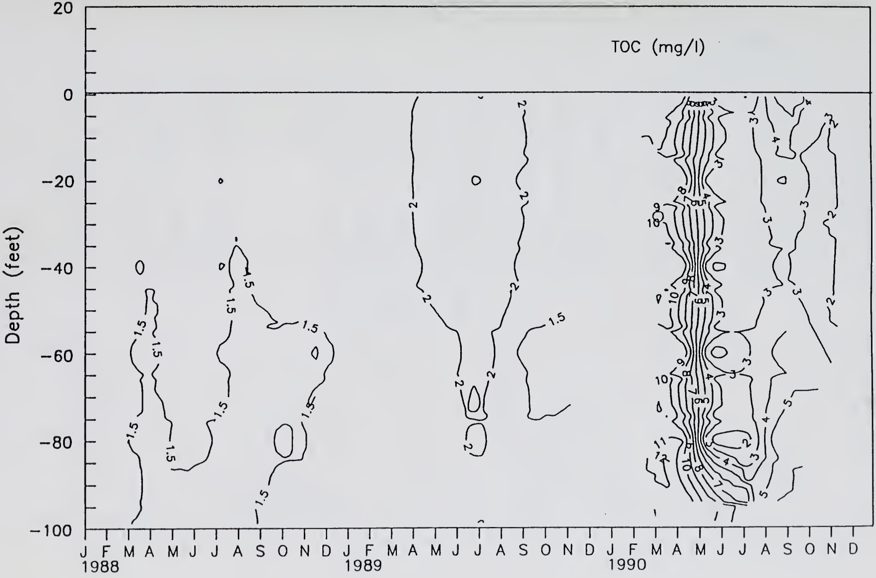
Lower Crystal Spring



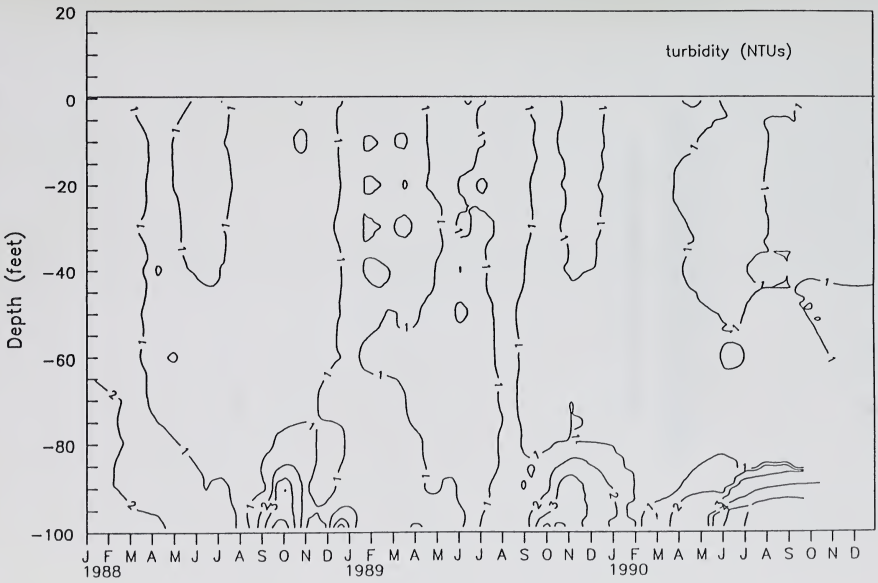
Lower Crystal Spring



Lower Crystal Spring

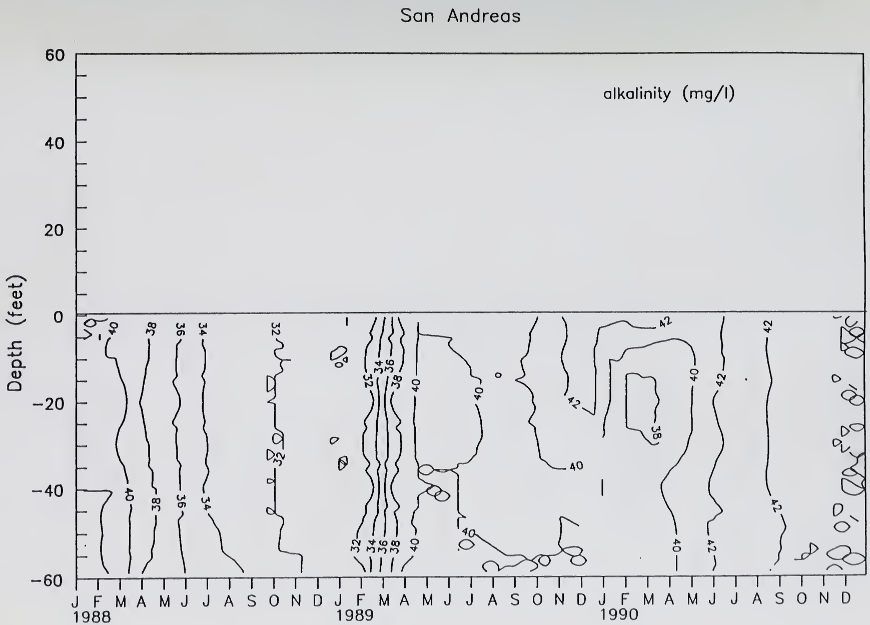


Lower Crystal Spring

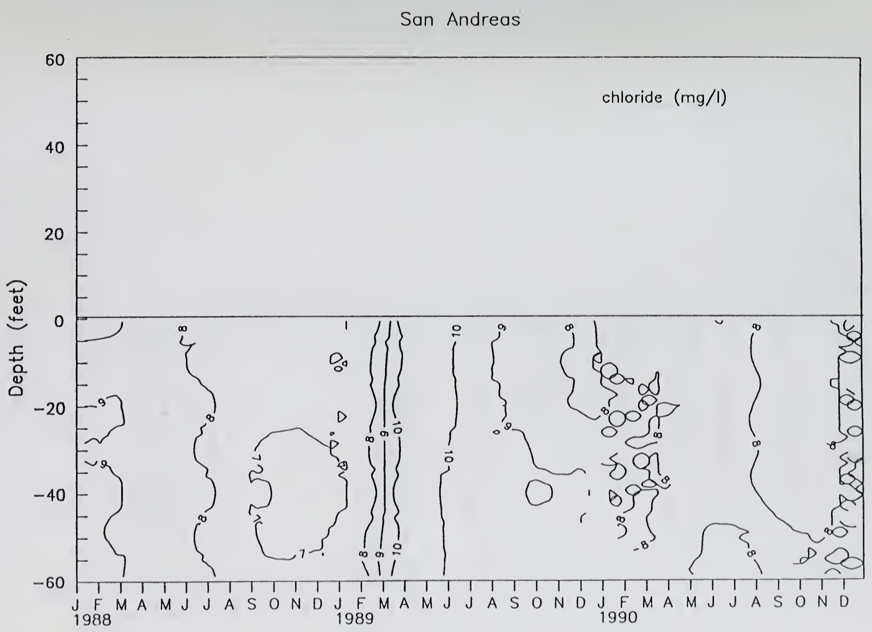


LIMNOLOGY WATER QUALITY
DEPTH PROFILES AND ISOPLETHS

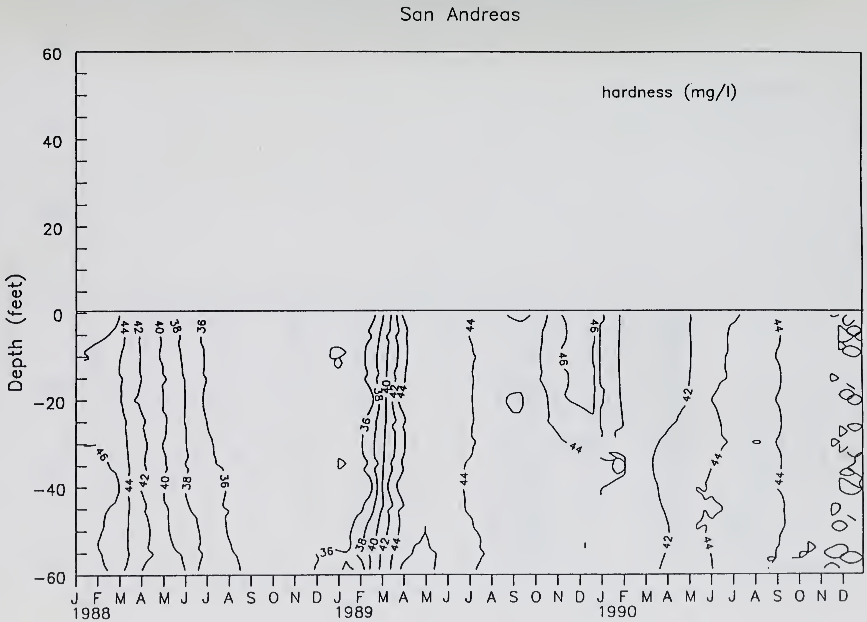
SAN ANDREAS RESERVOIR



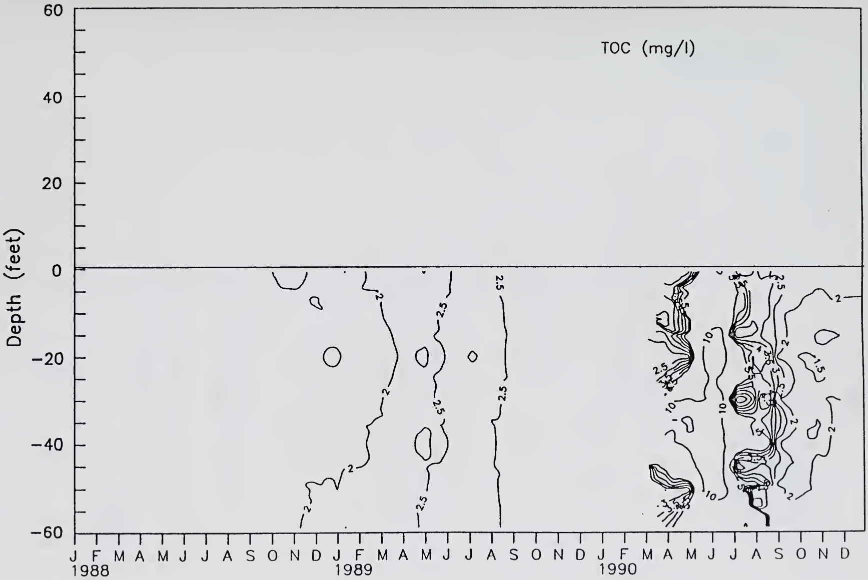
San Andreas
alkalinity (mg/l)
Depth (feet)
60
40
20
0
−20
−40
−60
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990



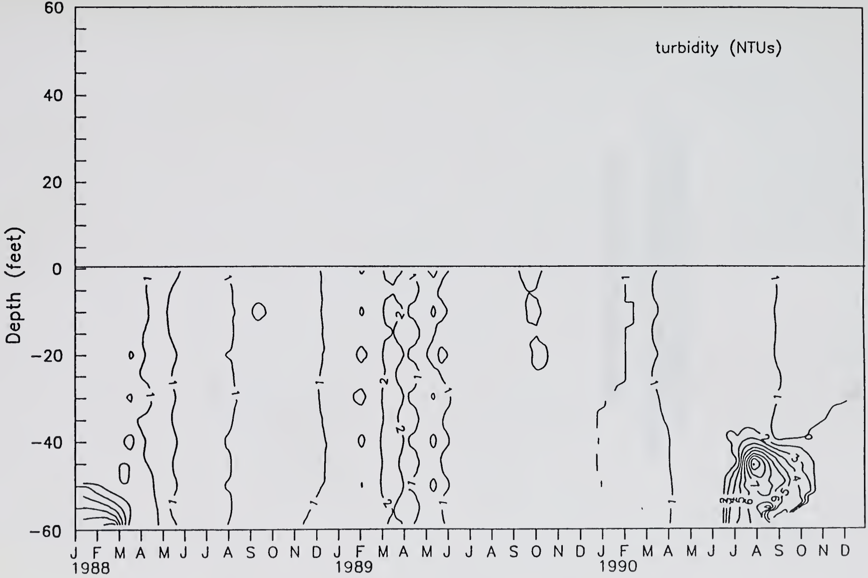
San Andreas
chloride (mg/l)
Depth (feet)
60
40
20
0
-20
-40
-60
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990


San Andreas
hardness (mg/l)
Depth (feet)
60
40
20
0
−20
−40
−60
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990
36
38
40
42
44
46

San Andreas


TOC (mg/l)
Depth (feet)
60
40
20
0
-20
-40
-60
J F M A M J J A S O N D
1988
1989
1990

San Andreas

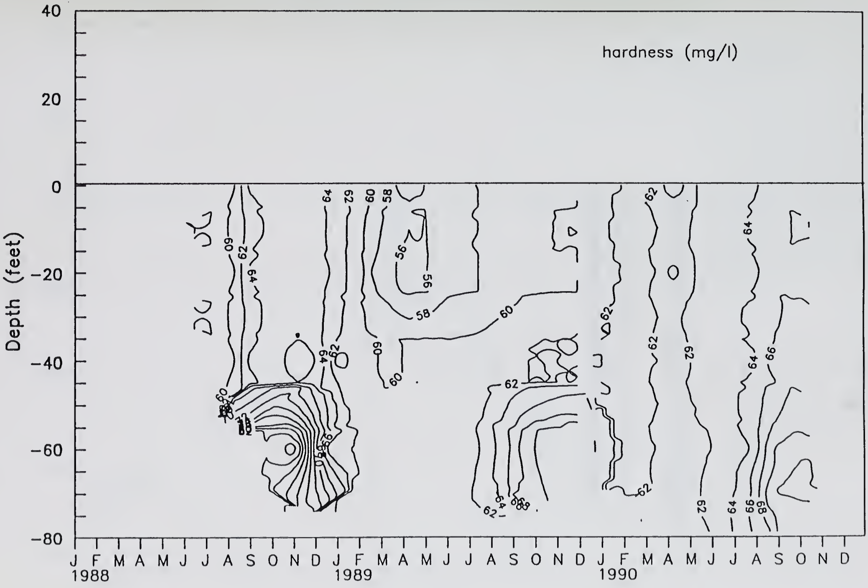


turbidity (NTUs)
Depth (feet)
60
40
20
0
-20
-40
-60
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990

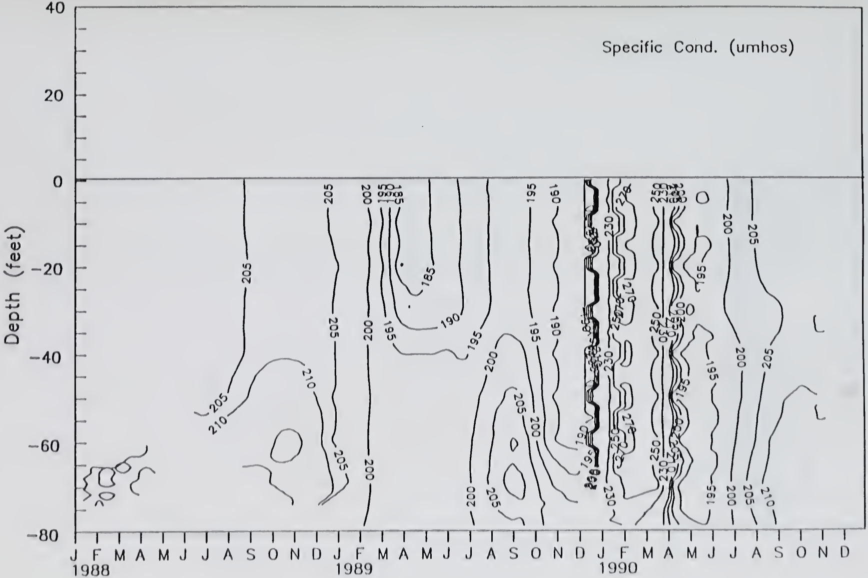
LIMNOLOGY WATER QUALITY
DEPTH PROFILES AND ISOPLETHS

PILARCITOS RESERVOIR

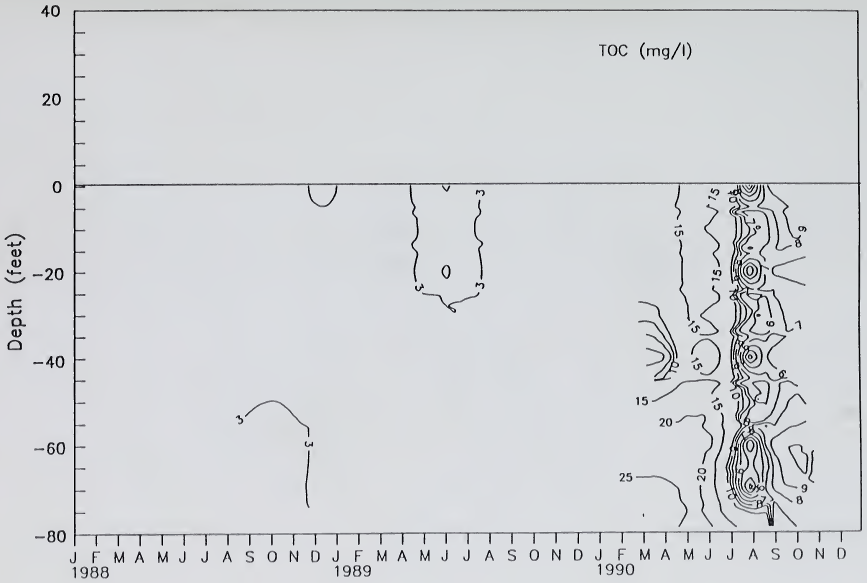
Pilarcitos


hardness (mg/l)
Depth (feet)
40
20
0
-20
-40
-60
-80
J F M A M J J A S O N D
1988
J F M A M J J A S O N D
1989
J F M A M J J A S O N D
1990
56
58
60
62
64
66
68

Pilarcitos

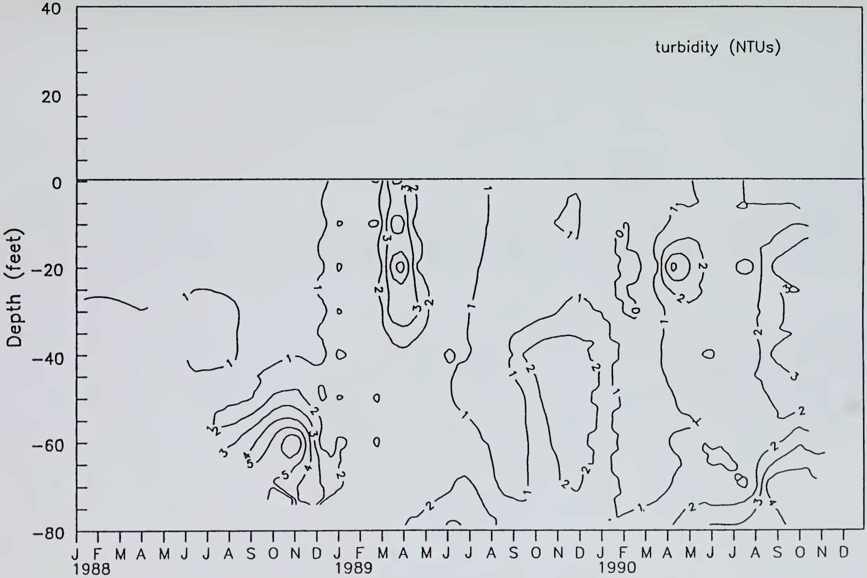

Specific Cond. (umhos)
Depth (feet)
40
20
0
-20
-40
-60
-80
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990

Pilarcitos



TOC (mg/l)
Depth (feet)
40
20
0
-20
-40
-60
-80
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990

Pilarcitos


turbidity (NTUs)
Depth (feet)
40
20
0
−20
−40
−60
−80
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1988
1989
1990

APPENDIX D

WATER QUALITY VULNERABILITY ZONE DEVELOPMENT

MONTGOMERY WATSON

TECHNICAL MEMORANDUM NO. 5

TO:	Ed Stewart, SFWD Dave Blau, EDAW Tina Stott, EDAW	**DATE:**	25 March 1994
PREPARED BY:	Carol Ruth James Karen Johnson	**CLIENT:**	EDAW, Inc.
REVIEWED BY:	San Francisco Water Department Watershed Planning Committee and Technical Advisory Committee	**FILE:**	637.0040/6.1
SUBJECT:	Water Quality Vulnerability Zone Development		

INTRODUCTION

Technical Memorandum No. 5 summarizes the development process for the water quality vulnerability zone maps. This memorandum is divided into two sections:

- A section which documents the natural watershed characteristics which influence each water quality parameter group of concern, and
- A section which discusses the method used for compositing the natural watershed characteristics into water quality parameter vulnerability zone maps.

In order to develop a tool for determining watershed lands vulnerable to current and potential future activities within the San Francisco Water Department's Peninsula and Alameda watersheds, five water quality parameter groups were selected for the evaluation. These water quality parameter groups were selected based on current and potential water quality regulations, industry-wide water quality issues, and the current activities within each watershed. The five groups include: particulates, synthetic organic compounds (SOCs) and pesticides, microorganisms, trihalomethane (THM) precursors, and nutrients (nitrogen and phosphorus).

For each of these five water quality parameter groups, three to five watershed characteristics were evaluated regarding their potential influence on the concentrations of these parameter groups in the watershed waterbodies as a result of potential future watershed activities. These five watershed characteristics include: soils, slope, vegetation, proximity to water bodies, and wildlife concentrations (cattle included). The relative importance of each of these characteristics for each water quality parameter group is summarized.

The goal of this evaluation is to develop a vulnerability zone map for each water quality parameter group for both watersheds. These vulnerability zone maps identify those areas in the

[illegible]

watershed which are considered high, medium, and low vulnerability zones with regards to their potential for increasing the concentration of a particular water quality parameter group in the receiving waterbodies. Activities within the waterbodies were not a component of this study but should be considered in the overall watershed management plan. For example, birds which use the waterbodies, particularly waterfowl, defecate directly into the waterbodies and, therefore, have a direct impact on water quality.

In order to develop the water quality vulnerability zone maps, GIS data for each characteristic were evaluated and ranked as high, medium, and low and plotted on a separate GIS data-interpreted layer. These layers were then combined and an overall high, medium, and low vulnerability zone map was developed for each water quality parameter group. A discussion of the development of these layers for each water quality parameter group is provided in the "Water Quality Parameter Groups" section.

CONCLUSIONS

Composite water quality vulnerability zones were developed for the five water quality parameter groups - particulates, SOCs and pesticides, microorganisms, THM precursor (surrogate for all disinfection by-product precursors), and nutrients. These vulnerability zones were defined based on five physical characteristics of each watershed - soils, slope, vegetation, proximity to water, and wildlife concentration areas. Through this analysis we determined that inadequate data exists regarding wildlife movement within the watershed, and the proximity to water characteristic includes a broad enough boundary around all water bodies (reservoirs and streams, including intermittent creeks) such that a separate wildlife concentration area need not be defined at this time. However, as additional wildlife information becomes available in the future, a wildlife vulnerability zone should be developed. Another finding is that the available data for both THM precursors and nutrients is limited to the extent that the vulnerability zones for these two water quality groups are identical. In order to better define these two water quality zones, monitoring for total organic carbon, nitrogen, and phosphorus would need to be inititated.

Ultimately the water quality vulnerability zones were composited based upon the approach summarized below.

- The high vulnerability areas defined for the "proximity to water" layer take precedence and, therefore, are defined as high vulnerability zones on all water quality composite maps.

- For other areas to be defined as a "high", slope must be high and either soils or vegetation must be high.

- For areas to be defined as a "low", two of either slope, soils, or vegetation must be low.

- All other areas not already defined based on the three points above are defined as medium.

Verification of this approach was achieved by using evaluation tools from both the agricultural (Universal Soil Loss Equation) and forestry (Erosion Hazard Rating) industries. The agricultural tool was the most compatible because of its emphasis on soils (such as clays) which can be more easily transported and cause treatment related water quality problems. Both evaluation tools placed importance on slope and its potential for impacting water quality. As a result of the verification step, the water quality vulnerability zones have been finalized and are now being used in the development of the watershed management plan alternatives.

In final, it will be important for a watershed/reservoir monitoring program to be developed and initiated as soon as is possible. A water quality baseline is important to establish in the near term for two reasons. First, an assessment can be made regarding the water qualities of the sources as they enter the SFWD-owned portion of the watersheds - particularly the Alameda Watershed.

[illegible]

Two-thirds of the Alameda Watershed are owned by other parties and, therefore, SFWD cannot directly control the water qualities influenced by these properties.

Second, once a watershed management plan is established, monitoring will be a tool for evaluating the plan. Having a baseline of data and a monitoring program which is established for this assessment will be important. Current monitoring programs do not address this need.

WATER QUALITY PARAMETER GROUPS - IMPACTS OF NATURAL WATERSHED CHARACTERISTICS

Particulate Vulnerability Zone

The impact of each of the following watershed characteristics on particulate vulnerability was defined by the tendency of the characteristic to influence particle transport.

- **Soils** - high, medium, and low classifications for soils were defined based on the inverse of the dry density of each soil type. Dry density refers to the mass (weight) of a unit volume of dry soil. Dry density was chosen over both bulk (includes solids and pores) and particle density (includes solids) because of its universal use and availability. In addition, it was assumed that the highest increase of particulates into the waterbodies due solely to the soil-type occurs with the first major storm event when the dry density is more apt to represent the soils. In general, clays which have a low dry density are classified as high, loams which have a medium dry density are classified as medium, and sands/gravels which have a high dry density are classified as low.

- **Slope** - high, medium, and low classifications for the slope ranges were defined based on the US Forest Service classifications for debris slumping or increased particle transport. These slope ranges are different than those used for sediment yield analyses (debris avalanche). In sediment yield analyses the evaluation is focused on mass loadings of sediment.

high	greater than 30 %
medium	15 to 30 %
low	0 to 15 %

- **Vegetation** - high, medium, and low classifications for vegetation were determined based on the ability of the different vegetation communities to provide a protective layer (intercept the kinetic energy) between rainfall and soil and to a lesser degree, stabilize the soils with the presence of leaf debris and roots. Given this line of reasoning, forested areas were considered the most protective (low), woodlands, scrubs and chaparral medium (medium), and grasses the least protective (high).

- **Proximity to Water** - the "proximity to water" boundary was established based on three sources of information -- other watershed investigations, rainfall intensity and time of concentration.

  Watershed Investigations - most current "proximity to water" information pertaining to watershed studies identifies buffer zones for development purposes as a barrier for protecting water quality. Information pertaining to watershed studies documented in the AWWA Effective Watershed Management manual and a study conducted in Taiwan which, in part, addressed this issue, were used. A range of 50 to 300 feet was ascertained as the distance required to adequately impede the movement of particulates, nutrients, and pesticides into the watershed waterbodies. This range of distances would also be adequate for the control of microorganisms - impeding their movement into the water bodies. These distances, of course, are greatly impacted by type of vegetation, slope, and soil types. However, these physical watershed characteristics are already addressed in the other vulnerability zones discussed herein.

[illegible]

Reduction of the 300-foot distance is possible if establishing buffer zones as a control mechanism for land development is the goal of a particular study. However, in the San Francisco study, because protection of water quality is the predominant goal, the use of the 300-foot distance as the baseline proximity boundary is both defensible and considered prudent.

Rainfall Intensity - given that the intensity of rainfall plays an important role in the movement of particulates, the intensity of rainfall was determined for each of the five reservoirs. The rainfall intensity for each reservoir provides a basis for developing a relationship between the five reservoirs regarding the "proximity to water" boundary distance. Based on the average 24-hour maximum rainfall for various periods reported for each reservoir, the following rainfall intensities were defined. These intensities suggest that San Antonio Reservoir would likely have the shortest proximity to water boundary and Pilarcitos Reservoir the longest.

Reservoir	Rainfall Intensity (inches/24-hour period average maximum)
San Antonio	1.67
Calaveras	1.81
Crystal Springs	2.57
San Andreas	3.16
Pilarcitos	3.71

Time of Concentration - Time of concentration is a technically accurate approach for comparing the relative differences in precipitation and, also, the relative differences in land surface characteristics. Because the movement of particulates is due to overland runoff, the proximity to water classification is actually a function of the overland flow characteristics - characteristics of the land and rainfall event. The most important land surface characteristics are slope, soil type, soil moisture, and roughness of the land. The most important rainfall characteristics are intensity and duration of the rainfall event. Time of concentration incorporates these characteristics to varying degrees. A detailed discussion of this analysis can be found in the Appendix. Below is a summary of the time of concentrations and the corresponding proximity to water boundaries defined for each reservoir. As suggested by the rainfall intensity data and confirmed by the time of concentration analysis, the San Antonio Reservoir has the shortest and Pilarcitos Reservoir the longest proximity to water boundaries.

Reservoir	Duration (Tc) of 1.3 "/hr storm (minutes)	Proximity to Water (feet)
San Antonio	11.5	300
Calaveras	12	380
Crystal Springs	18	600
San Andreas	20	900
Pilarcitos	25	1,300

Given this information, the following classifications were defined for the proximity to water vulnerability zones.

high 0 to 1,300 feet from the high water line of the reservoir (maximum value varies depending upon the reservoir, see above)

0 to 1,300 feet from the centerline of stream (maximum value varies depending upon in which precipitation isoline a particular tributary is located)

medium a medium classification was not defined for this characteristic because it was not deemed defensible

low areas outside the 300 to 1,300-foot proximity and within 2,000 feet of SFWD owned lands

- **Wildlife Concentration Areas** - those areas which are identified as having high wildlife concentrations were intended to be targeted as high vulnerability zones because of the disturbance caused to the soils which may increase particle transport. In part, these areas are included in the proximity to water layer because mammals must travel to and from the reservoirs for water. Data were insufficient to allow any further classifications to be made outside the proximity to water layer.

SOCs and Pesticides Vulnerability Zone

The impact of each of the following watershed characteristics on SOC and pesticide vulnerability was defined by the tendency of the characteristic to influence SOC and pesticide transport into the waterbodies as a result of an activity within the watershed. SOCs and pesticides are assumed to either be present in an aqueous form or adsorbed onto the soil. SOC and pesticide transport, therefore, occurs through either aqueous or particle transport.

- **Soils** - based on the transport mechanisms mentioned above, the impact of soils on SOC and pesticide transport is influenced by the soil's permeability and adsorptive capacity. If a soil has a low permeability then ponding may occur which means aqueous transport is a viable transport mechanism. If a soil has a high adsorption capacity then particle transport becomes the important transport mechanism.

  Adsorption capacity refers to the ability of a particular soil to adsorb a chemical. The cation exchange capacity of each soil was used as an indicator of adsorption capacity.

  In general, soils with low permeability have high adsorption capacity. For example, clays tend to have low permeability and high adsorption capacity, loams medium, and sands/gravel have high permeability and low adsorption capacity. This relationship suggests parallel relationships between the soils' high, medium and low classificiations for both of these characteristics. Therefore, clays would have a high classification, loams a medium classification and sands/gravel a low classification.

  The one exception to this interpretation of the impact of soils on SOCs and pesticides is the consideration pertaining to groundwater. In general, those soils with high permeability would have a high vulnerability because they would allow the SOCs and pesticides to penetrate down to the groundwater aquifer. This is an opposite interpretation of permeability and its impact on surface water. This concern regarding groundwater, however, is included in the definition of the proximity to water layer.

- **Slope** - because both the aqueous and particle transport mechanisms are important for SOC and pesticide transport, slopes which enhance runoff versus particle transport were used as the criteria for establishing the high, medium, and low classifications. Storm water management design criteria were used to define the ranges summarized below.

  high greater than 30 %
  medium 10 to 30 %
  low 0 to 10 %

- **Vegetation** - high, medium, and low classifications for vegetation were determined based on the ability of the different vegetation communities to provide a protective layer between rainfall and soil - soils which may contain adsorbed SOCs/pesticides thus reducing particle transport. Given this line of reasoning, forested areas were considered the most protective (low), woodlands, scrubs and chaparral medium (medium), and grasses the least protective (high).

- **Proximity to Water** - the justification for selecting the proximity classification below is summarized under the Particulate Vulnerability Zone section. In addition, a high classification was established for the Sunol Valley aquifer. The ease of transport of SOCs and pesticides through alluvial deposits into the upper aquifer, which is considered "under the influence of surface water", and the potential impact of SOCs and pesticides on downstream users were influential in this decision.

  high 0 to 1,300 feet from the high water line of the reservoir (maximum value varies depending upon the reservoir, see above)

  0 to 1,300 feet from the centerline of stream (maximum value varies depending upon in which precipitation isoline a particular tributary is located)

  Sunol Valley - alluvial valley defined as the 360-foot contour, where alluvial soils are present

  medium a medium classification was not defined for this characteristic because it was not deemed defensible

  low areas outside the 300 to 1,300-foot proximity and within 2,000 feet of SFWD owned lands

- **Wildlife Concentration Areas** - those areas which are identified as having high wildlife concentrations were intended to be targeted for consideration in developing the overall SOC/pesticide vulnerability zones. The disturbance caused to soils - which may contain adsorbed SOCs/pesticides - is the key issue and their ultimate transport into the waterbodies. In part, these areas are included in the proximity to water layer because mammals must travel to the reservoirs for water. Data were insufficient to allow any further classifications to be made outside the proximity to water layer.

Microorganisms Vulnerability Zone

The impact of each of the following watershed characteristics on microorganism vulnerability was defined by the tendency of the characteristic to increase microbiological survival and ultimate transport into the waterbodies within each watershed. The microorganisms of concern include total coliforms, *Giardia* and *Cryptosporidium*. Because of the difficulty in treating *Cryptosporidium*, when compared to total coliforms and *Giardia*, emphasis was placed on this microbe when the vulnerability zones were defined for each watershed characteristic below.

- **Soils** - when considering microorganism survival in a non-waterbody environment, moisture content, nutrients (carbon, nitrogen and phosphorus) and pH were considered important environmental conditions. Of these three, moisture content is considered the most important for *Cryptosporidium* survival (*Cryptosporidium* is known to survive in moist environments for up to six months without entering a waterbody). Therefore, moisture content defined by available water capacity or water-holding capacity was used as the soil characteristic of interest. Available water capacity or water-holding capacity is defined by the U.S. Soil Conservation Service. In general, clay has a high moisture content, loam a medium content, and sand/gravel a low moisture content.

- **Slope** - The two transport mechanisms being considered for this project include aqueous and particle transport. Microorganisms are assumed to fall into the particle transport category. Therefore, the high, medium, and low classifications for the microorganism slope ranges were defined based on increased particle transport.

high	greater than 30 %
medium	15 to 30 %
low	0 to 15 %

- **Vegetation** - high, medium, and low classifications for vegetation were determined based on the ability of the different vegetation communities to provide a protective layer from sunshine, thereby providing for higher moisture conditions to exist which will allow *Cryptosporidium* to survive longer. Given this line of reasoning, forested areas were considered the most protective (high), woodlands, scrubs and chaparral medium (medium), and grasses the least protective (low) from the sun.

- **Proximity to Water** - the justification for selecting the proximity classification below is summarized under the Particulate Vulnerability Zone section.

  high 0 to 1,300 feet from the high water line of the reservoir (maximum value varies depending upon the reservoir, see above)

  0 to 1,300 feet from the centerline of stream (maximum value varies depending upon in which precipitation isoline a particular tributary is located)

  medium a medium classification was not defined for this characteristic because it was not deemed definsible

  low areas outside the 300 to 1,300-foot proximity and within 2,000 feet of SFWD owned lands

- **Wildlife Concentration Areas** - those areas which are identified as having high wildlife concentrations and which are near the waterbodies will be targeted for consideration in developing the overall microorganism vulnerability zones. It is these areas where high concentrations of mammals, such as cattle and deer, may pass to drink water. It is assumed that these areas are where higher concentrations of waste products can be found which, in turn, reflects the potential for a higher source area for microorganisms. These areas are included in the proximity to water layers.

THM Precursor Vulnerability Zone

The impact of each of the watershed characteristics on THM precursor vulnerability was defined by the tendency of the characteristic to influence THM precursor loading and transport into the waterbodies within each watershed. THM precursors refers to the natural organic carbon which exists in each watershed in the form of decaying vegetation, bark, and animal carcasses as well as animal wastes. THM precursor is the terminology being used to represent the precursor for disinfection by-products (DBPs) in general -- THMs are the most well known DBPs.

These THM precursors can occur in one of several forms: decaying, decayed and mixed in with the soil, decayed and adsorbed onto soil, and/or decayed and existing in a dissolved form in water. Given these various forms, the non-dissolved forms would represent the majority of the THM precursors of most concern from a land management water quality perspective. Given this assumption, then particle transport is the most likely mechanism for moving THM precursors into the waterbodies, however, some movement occurs through aqueous transport.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

- **Soils** - the natural organic content, defined by the natural fertility of each soil, was determined based on information in soil survey manuals. Given that data pertaining to the organic carbon content of soils in the watersheds is either non-existent or very limited, natural fertility was used as opposed to organic carbon. In general, clay has a high natural fertility, loam a medium natural fertility, and sand/gravel a low natural fertility.

- **Slope** - since THM precursors are present in dissolved and particulate forms, it was assumed that slopes which increase runoff will determine the high, medium, and low slope classifications.

high	greater than 30 %
medium	10 to 30 %
low	0 to 10 %

- **Vegetation** - vegetation was considered from two different perspectives -- its contribution to the organic carbon content through litter decomposition and its protective capabilities regarding rainfall and erosion. With respect to its organic carbon content, information pertaining to the organic carbon content and ease of decay of the vegetation communities is non-existent. Data, limited as it is, is only available for specific vegetation species and, therefore, could not be incorporated into this analysis. Therefore, the vegetation communities were evaluated according to their ability to protect the ground from intense rainfalls, which in turn decreases the transport of THM precursor material. Following this line of reasoning, forested areas were considered the most protective (low), woodlands, scrubs and chaparral medium (medium), and grasses the least protective (high).

- **Proximity to Water** - the justification for selecting the proximity classification below is summarized under the Particulate Vulnerability Zone section.

high	0 to 1,300 feet from the high water line of the reservoir (maximum value varies depending upon the reservoir, see above)
	0 to 1,300 feet from the centerline of stream (maximum value varies depending upon in which precipitation isoline a particular tributary is located)
medium	a medium classification was not defined for this characteristic because it was not deemed definsible
low	areas outside the 300 to 1,300-foot proximity and within 2,000 feet of SFWD owned lands

- **Wildlife Concentration Areas** - those areas which are identified as having high wildlife concentrations were intended to be targeted for consideration in developing the overall THM Precursor vulnerability zones. The disturbance caused to soils - which contain organic carbon - is the key issue and their ultimate transport into the waterbodies. In part, these areas are included in the proximity to water layer because mammals must travel to the reservoirs for water. Data were insufficient to allow any further classifications to be made outside the proximity to water layer.

Nutrient Vulnerability Zone

The impact of each of the watershed characteristics on nutrient vulnerability was defined by the tendency of the characteristic to influence nutrient loading in the watershed and readily transport nutrients into the waterbodies.

Nutrients refer to the nitrogen and phosphorus which exists in each watershed. Nutrient sources include vegetation, soils, and animal wastes. The nutrients associated with vegetation matter can

only enter the waterbodies if the vegetation releases it during the decaying process. Nutrients, therefore, are associated with decaying vegetation matter and animal wastes, adsorbed onto soils, or leached through runoff. Given these various forms, the nutrients adsorbed onto soils are probably the most abundant which suggests that particle transport is the predominant mechanism for moving them into the waterbodies.

- **Soils** - the nutrient loading for each soil, defined by the natural fertility of each soil, was determined based on information in the soil survey manuals. Given that data pertaining to the nitrogen and phosphorus content of soils in the watersheds is either non-existent or very limited, natural fertility was used as opposed to nutrient loading. In general, clay has a high natural fertility, loam a medium natural fertility, and sand/gravel a low natural fertility.

- **Slope** - since nutrients are present in both dissolved and particulate forms it was conservatively assumed that slopes which increase runoff will determine the high, medium, and low slope classifications.

  high greater than 30 %
  medium 10 to 30 %
  low 0 to 10 %

- **Vegetation** - vegetation was considered from two different perspectives -- its contribution to the nutrient loading and its protective capabilities regarding rainfall. With respect to its nutrient loading, specific information pertaining to the nutrient loading to soils through litter decomposition or to runoff by leaching versus the cycling of nutrients through vegetation is not available in a format required for this project. Data, limited as it is, is only available for certain specific vegetation species - not communities - and, therefore, could not be incorporated into this analysis. Instead the vegetation communities were evaluated according to their ability to protect the ground from intense rainfalls, which in turn decreases the transport of nutrients. Following this line of reasoning, forested areas were considered the most protective (low), woodlands, scrubs and chaparral medium (medium), and grasses the least protective (high).

- **Proximity to Water** - the justification for selecting the proximity classification below is summarized under the Particulate Vulnerability Zone section.

  high 0 to 1,300 feet from the high water line of the reservoir (maximum value varies depending upon the reservoir, see above)

  0 to 1,300 feet from the centerline of stream (maximum value varies depending upon in which precipitation isoline a particular tributary is located)

  medium a medium classification was not defined for this characteristic because it was not deemed definsible

  low areas outside the 300 to 1,300-foot proximity and within 2,000 feet of SFWD owned lands

- **Wildlife Concentration Areas** - those areas which are identified as having high wildlife concentrations and which are near the waterbodies were targeted for consideration in developing the overall nutrient vulnerability zones. It is these areas where high concentrations of mammals, such as cattle and deer, may pass to drink water. It is assumed that these areas are where higher concentrations of waste products can be found which, in turn, reflects the potential for a higher source area for nutrients, particularly nitrogen. In part, these areas are included in the proximity to water layer because mammals must travel to the reservoirs for water. Data were insufficient to allow any further classifications to be made outside the proximity to water.

WATERSHED CHARACTERISTICS COMPOSITING METHOD - RATIONALE AND VERIFICATION

Table 1 is a summary of the relationships between the five watershed characteristics and the five water quality parameter groups. The rationale for combining the information from each of these five watershed characteristics is discussed below. Five composite water quality vulnerability zone maps are the result of this combination of information, however, the THM Precursor and Nutrient Loading maps are identifical due to the lack of pertinent data at this time.

In order to develop a rationale for the compositing approach, the roles of the five watershed characteristics were defined as summarized below.

Soils	Source/Influence/Transport
Vegetation	Transport/Source
Slope	Transport
Proximity to Water	Transport
Wildlife Concentrations	Influence/Source

"Source" is defined as the watershed characteristic which is the originator of the water quality parameter group being considered (eg. wildlife concentrations are a source of microorganisms). "Influence" indicates the watershed characteristic which enhances the survival or movement into the waterbodies of the water quality parameter group. "Transport" indicates the watershed characteristic which significantly increases the movement of the water quality parameter group into the waterbodies.

Of these three roles, transport is the most important followed by source and then by influence. In support of this concept is the following rationale, a water quality parameter of concern will never be an issue if it does not reach the waterbodies. As a corollary, a water quality parameter which is perceived as a non-issue may become a concern because it reaches the waterbodies. Given the relative importance between the three roles the following rationale was developed for the composite vulnerability zone maps.

Rationale

Numerical weighting factors were avoided as a tool to be used in the composite approach because of the subjective nature associated with the assignment of the numerical values. It was determined that numerical weighting factors could become a source of criticism and ongoing discussion. Instead, identification of the relative importance of the specific watershed characteristics was used. Also, the high, medium, and low classifications given to the watershed characteristics were used.

Because of its importance to the control (reduction) of the concentration of water quality parameters entering the water bodies, the high vulnerability areas defined for the proximity to water layer will take precedence and, therefore, will be defined as high vulnerability zones on all the composite maps. Since the wildlife concentration area is included in the proximity to water layer, it will not be considered as a separate layer in the composite.

The remaining three watershed characteristics are soils, vegetation, and slope. For an area to be defined as a "high", slope must be high and either soils or vegetation must be high. For an area to be defined as a "low", two of the three remaining watershed characteristics must be low. All other areas will be defined as medium. In theory this concept makes sense and avoids the pitfalls which may arise out of using numerical weighting factors -- the exact values of which can always be disputed.

WATER QUALITY PARAMETER GROUPS	WATERSHED CHARACTERISTICS				
	Soils	Vegetation	Slope	Proximity to Water	Wildlife Concentration (includes cattle)
Particulates	Dry Density	Protective Layer	Particulate Transport	Rainfall Intensity	Included in Proximity to Water
SOCs	Adsorption Capacity	Protective Layer	Increased Runoff	Rainfall Intensity plus Alluvial Valley	Included in Proximity to Water
Microorganisms	Moisture Content	Protective Layer	Particulate Transport	Rainfall Intensity	Included in Proximity to Water
THM Precursors	Natural Fertility	Protective Layer	Increased Runoff	Rainfall Intensity	Included in Proximity to Water
Nutrient Loading	Natural Fertility	Protective Layer	Increased Runoff	Rainfall Intensity	Included in Proximity to Water

**RELATIONSHIPS BETWEEN
WATERSHED CHARACTERISTICS AND
WATER QUALITY VULNERABILITY ZONE DEVELOPMENT**

TABLE 1

Verification

In order to verify this rationale for developing the water quality vulnerability zones, two empirically based evaluation techniques were used. One technique, the Universal Soil Loss Equation (USLE), is a common tool used by the agricultural industry. The second technique, the Erosion Hazard Rating (EHR) System, is a common tool used by the forestry industry. As yet a technique has not been developed for the water quality industry, therefore, both of these techniques were used. While both techniques take into account erosion potential, the agricultural industry technique more closely relates to water quality concerns because it places a higher weighting on the soil types (clays, loams) which are more easily transported and ultimately can become a water quality/treatment problem. The forestry industry technique, on the other hand, places emphasis on soils (sand, gravel) which may erode more easily, but tend to settle out more easily once they enter a water body and ultimately do not necessarily present water quality/treatment problems. Both techniques consider slope to be an important characteristic. However, the ULSE is oriented toward slopes in the ranges considered herein (0 to 30%) while the EHR System is oriented toward even higher slopes (40 to 80%) which are important for major movements of sediment. Given these points, the agricultural technique was used as the main verification tool with the forestry technique being used as a further verification check.

Universal Soil Loss Equation. The USLE is typically presented as:

$$A = R\,K\,L\,S\,C\,P,$$

where: A is the estimated soil loss,
R is the erosivity of the rainfall,
K is the soil erodibility,
L is a slope length factor,
S is the slope steepness factor,
C is a cover management factor, and
P is a supporting practices factor.

In order to develop a general weighting approach for all five watersheds the following factors are assumed equal or constant between the five reservoirs: R, L, and P factors. The formula is then simplified and is comprised of a relationship between soil loss and the three characteristics of slope, soil type, and vegetation. These characteristics correspond to the three highlighted above: soil, slope, and vegetation.

$$\text{Relative soil loss} = K\,S\,C$$

Given this relationship, for verification purposes, the three composite vulnerability classifications (high, medium, and low) developed from these three watershed characteristics must be evaluated according to accepted values for the three watershed characteristics used in the USLE.

Wischmeier, et.al., in the Journal of Soil and Water Conservation, 1971, developed a nomograph relating USLE K factor to soil type. For sandy soils (low vulnerability), this gives a K ranging between 0.10 and 0.25. For loamy soils (medium vulnerability), the nomograph gives a K value between 0.25 and 0.40. For clay soils (high vulnerability), a K value between 0.40 and 0.60 is indicated. Average range values were selected for the K factor corresponding to each of the soil types as follows:

Soil Type	Vulnerability	Average K Factor
Sandy soils	Low	0.175
Loamy soils	Medium	0.325
Clay soils	High	0.500

Verification

In order to verify this rationale for developing the water quality vulnerability zones, two empirically based evaluation techniques were used. One technique, the Universal Soil Loss Equation (USLE), is a common tool used by the agricultural industry. The second technique, the Erosion Hazard Rating (EHR) System, is a common tool used by the forestry industry. As yet a technique has not been developed for the water quality industry, therefore, both of these techniques were used. While both techniques take into account erosion potential, the agricultural industry technique more closely relates to water quality concerns because it places a higher weighting on the soil types (clays, loams) which are more easily transported and ultimately can become a water quality/treatment problem. The forestry industry technique, on the other hand, places emphasis on soils (sand, gravel) which may erode more easily, but tend to settle out more easily once they enter a water body and ultimately do not necessarily present water quality/treatment problems. Both techniques consider slope to be an important characteristic. However, the ULSE is oriented toward slopes in the ranges considered herein (0 to 30%) while the EHR System is oriented toward even higher slopes (40 to 80%) which are important for major movements of sediment. Given these points, the agricultural technique was used as the main verification tool with the forestry technique being used as a further verification check.

Universal Soil Loss Equation. The USLE is typically presented as:

$$A = R\,K\,L\,S\,C\,P,$$

where: A is the estimated soil loss,
R is the erosivity of the rainfall,
K is the soil erodibility,
L is a slope length factor,
S is the slope steepness factor,
C is a cover management factor, and
P is a supporting practices factor.

In order to develop a general weighting approach for all five watersheds the following factors are assumed equal or constant between the five reservoirs: R, L, and P factors. The formula is then simplified and is comprised of a relationship between soil loss and the three characteristics of slope, soil type, and vegetation. These characteristics correspond to the three highlighted above: soil, slope, and vegetation.

$$\text{Relative soil loss} = K\,S\,C$$

Given this relationship, for verification purposes, the three composite vulnerability classifications (high, medium, and low) developed from these three watershed characteristics must be evaluated according to accepted values for the three watershed characteristics used in the USLE.

Wischmeier, et.al., in the Journal of Soil and Water Conservation, 1971, developed a nomograph relating USLE K factor to soil type. For sandy soils (low vulnerability), this gives a K ranging between 0.10 and 0.25. For loamy soils (medium vulnerability), the nomograph gives a K value between 0.25 and 0.40. For clay soils (high vulnerability), a K value between 0.40 and 0.60 is indicated. Average range values were selected for the K factor corresponding to each of the soil types as follows:

Soil Type	Vulnerability	Average K Factor
Sandy soils	Low	0.175
Loamy soils	Medium	0.325
Clay soils	High	0.500

TABLE 2

VERIFICATION OF COMPOSITE RATIONALE BY USLE CALCULATION

COMPOSITE COMBINATIONS OF WATERSHED CHARACTERISTICS			CALCULATED ULSE FACTOR USLE = K S C	COMPOSITE RATIONALE RATING(1)
Soils	Vegetation	Slope		
High	High	High	3,647	High
High	Medium	High	2,553	High
Medium	High	High	2,370	High
Medium	Medium	High	1,659	Medium* - High (2)
Low	High	High	1,276	High
High	High	Medium	1,112	Medium
Low	Medium	High	893	Medium
High	Medium	Medium	778	Medium
High	Low	High	729	High
Medium	High	Medium	723	Medium
Medium	Medium	Medium	506	Medium
Medium	Low	High	474	Medium
Low	High	Medium	389	Medium
Low	Medium	Medium	272	Medium
Low	Low	High	255	Low* - Medium
High	Low	Medium	222	Medium
Medium	Low	Medium	145	Medium
High	High	Low	123	Medium
High	Medium	Low	86	Medium
Medium	High	Low	80	Medium
Low	Low	Medium	78	Low* - Medium
Medium	Medium	Low	56	Medium
Low	High	Low	43	Low
Low	Medium	Low	30	Low
High	Low	Low	25	Low
Medium	Low	Low	16	Low
Low	Low	Low	9	Low

(1) Composite Rationale defined previously in Watershed Characteristics Compositing Method Section.

(2) Asterisked composite rationale ratings indicate they were modified based on the verification evaluation.

[illegible]

Average values for each factor within each of the five watersheds were determined and input to this formula and the results compared to the composite rationale ratings in Table 2. Although this technique does not address drinking water quality concerns as closely as the agricultural technique of USLE, the results of the analysis do support the verification of the composite rationale. In addition, they also support the emphasis placed on slope and, therefore, the changes highlighted in Table 2 which were based on slope.

APPENDIX
PROXIMITY TO WATER VERIFICATION

The classification of watershed lands in terms of how close they are to a water body is based upon the typical distance over which particulates might move. Because the movement of particulates is due to overland runoff, the proximity to water classification is actually a function of the overland flow characteristics of the land surface.

Overland flow may be estimated using a number of different techniques, from a simple rational method approach to sophisticated deterministic rainfall runoff models. In any of these techniques, the important factors driving the overland flow are the characteristics of the land surface and the characteristics of the rainfall event. The most important land surface characteristics are slope, soil type, soil moisture, and roughness of the land. The most important rainfall characteristics are intensity and duration of the rainfall event.

If all of the watershed lands had the same surface characteristics, the overland flow, and hence the movement of particulates, would simply be a function of the intensity of the rainfall and duration of the rainfall event. And, if we assume that a certain rainfall intensity is necessary in order to move particulates, the amount of material moved into the water body is directly related to how long that intensity lasts. For example, if one rainfall event lasts twice as long as another, then material may travel from twice as far away, and thus twice as much material may enter the water body.

A minimum distance of 300 feet from the high water line has been established as defining the limit of the high proximity to water vulnerability zone for the San Antonio Reservoir. Comparable proximity distances were established for the other watersheds, based upon the differences in their relative average 24-hour maximum precipitation as compared to the San Antonio Reservoir.

A more technically accurate approach is to compare the relative differences in precipitation and, also, the relative differences in land surface characteristics. In order to accomplish this comparison, the time of concentration was calculated for each reservoir. The time of concentration (Tc) of a basin is used in this analysis as a measure of how long rainfall must continue until all of a designated area within a basin is contributing runoff. The formula for Tc used in this analysis is defined below. This Tc formula is one of the first, and most widely used, relationships proposed for use with ungauged watersheds, developed by C. E. Ramser (1927).

$$Tc = [2.2\, n\, (Lo) / (So)^{.5}]^{0.467}$$

where: n is the Manning's roughness coefficient
Lo is the overland distance from the point of farthest contribution in meters
So is the average slope

The equation can then be rearranged and solved for Lo as follows.

$$Lo = 10^{[\mathrm{Log}(Tc)/.467 - \mathrm{Log}(2.2\, n / (So)^{0.5})]}$$

The estimated values used for Manning's roughness and slope for each of the watersheds are summarized below. Manning's roughness was varied based upon the identification of the predominant vegetation community (area-wise) which represents each of the five reservoirs. The corresponding values for Manning's roughness were obtained from Hydrologic Modeling of Small Watersheds by Haan, Johnson and Brakensier, ASAE, 1982.

Reservoir	Manning's Roughness	Average Slope (percent)
Pilarcitos	0.6	30
San Andreas	0.5	25
Crystal Springs	0.55	20
Calaveras	0.45	30
San Antonio	0.45	25

If we equate the Lo with our proximity to water characteristic on San Antonio Reservoir (Lo = 300 feet), the equation yields a Tc of 11.5 minutes. Precipitation records from the short interval precipitation station nearest San Antonio Reservoir show that the 2-year return interval, 11.5-minute storm has an intensity of 1.3 inches per hour.

Based on an analysis of precipitation records from all over California, James Goodridge (Bulletin No. 195, "Rainfall Analysis for Drainage Design", DWR, 1976) found a strong relationship between the intensity of heavy rainfall, the duration of rainfall, and the mean annual precipitation. By applying this relationship, it is possible to determine the duration of 1.3 inch per hour rainfall on the other watershed areas, corresponding to the two-year return period event at San Antonio Reservoir. A two-year return period was used because it is a common base frequency used for defining precipitation or rainfall events in watersheds.

Based upon the available rainfall records from stations near each reservoir, and modified to reflect reservoir area conditions, as needed, the corresponding rainfall durations, or Tc, having approximately a 1.3 inch per hour intensity, are defined for each reservoir as summarized below.

Reservoir	Duration of 1.3"/hr storm (minutes)
San Antonio	11.5
Calaveras	12
Crystal Springs	18
San Andreas	20
Pilarcitos	25

In turn, using these durations in the time of concentration formula as Tc and the Manning's Roughness coefficients (n) and average slopes (So) defined above for each reservoir, the overland flow distances (Lo), or proximity to water, corresponding to 300 feet at San Antonio Reservoir would be as defined below.

Reservoir	Proximity to Water (feet)
San Antonio	300
Calaveras	380
Crystal Springs	600
San Andreas	900
Pilarcitos	1,300

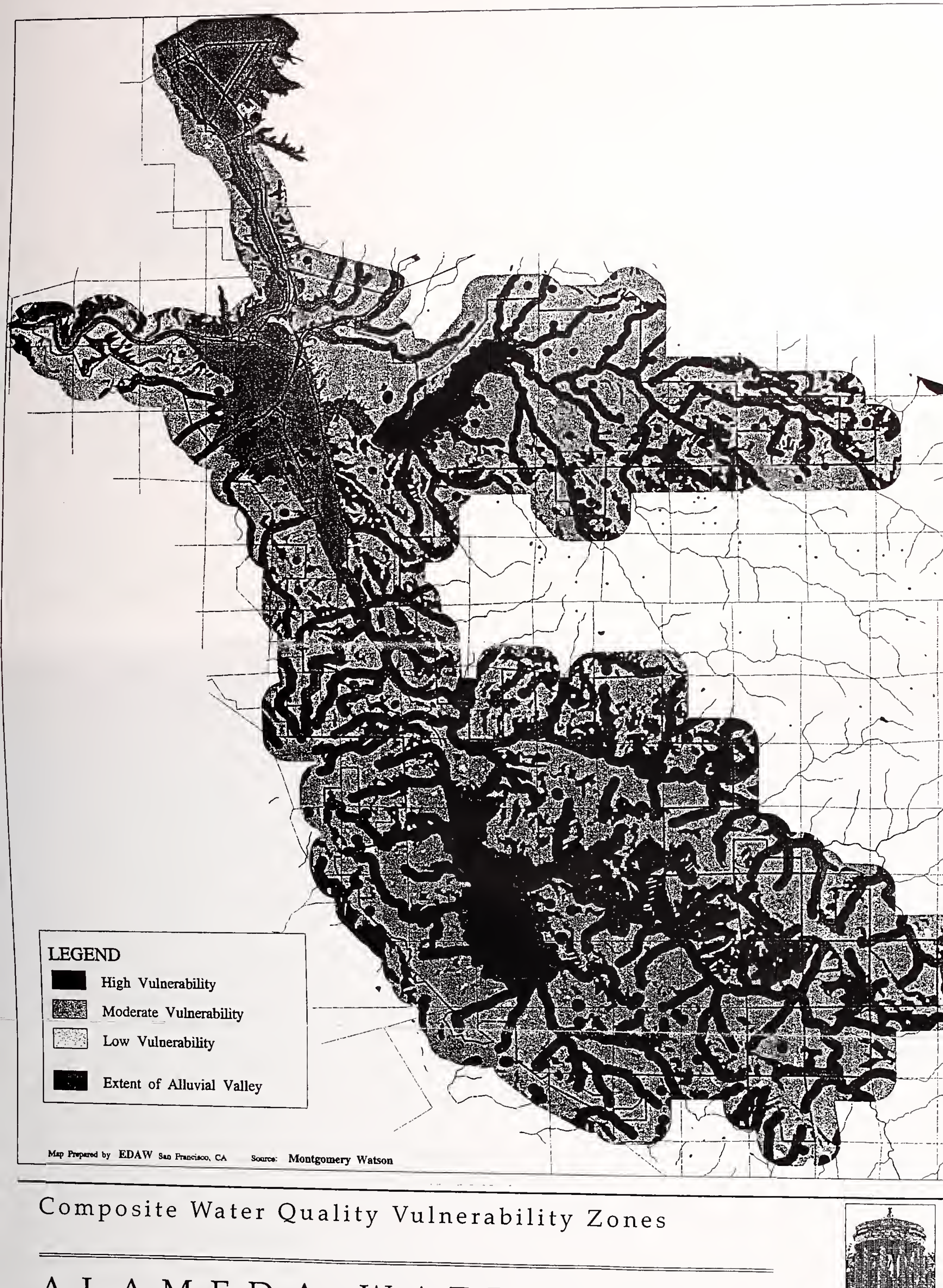
[illegible]

Composite Water Quality Vulnerability Zones

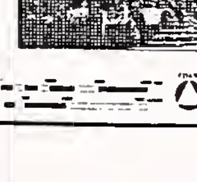
PENINSULA WATERSHED
SAN FRANCISCO WATERSHED MANAGEMENT PLANS

FIGURE D-1

3/25/94



Composite Water Quality Vulnerability Zones



ALAMEDA WATERSHED
SAN FRANCISCO WATERSHED MANAGEMENT PLANS

FIGURE D-2

APPENDIX E

REFERENCES

APPENDIX E

REFERENCES

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APPENDIX F

WATERSHED SANITARY SURVEY CONTRIBUTORS

APPENDIX F

WATERSHED SANITARY SURVEY CONTRIBUTORS

EDAW, Inc.
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